Honduran production systems and dietary impacts on carcass and harvest offal yields and value

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Abstract

Increasing world population has applied immense pressure on the global beef industry to generate more product efficiently with less waste. The need for increased food production leads to increased food security issues, encompassing a greater need for nutrients in the human diet, such as protein and iron. With a predominately lower income society, Honduras is in dire need of a larger and more efficient supply of protein. The purpose of this study was to study the possibility of increased red meat yield and carcass and subprimal value of a restricted product in Honduras: beef cattle. Honduran beef producers and faculty from Texas Tech University developed treatments by utilizing new diet constituents and local byproducts to improve efficiency and value of the beef animal. Five finishing programs were developed and selected which differ from the usual grass fed (GF) diet of cattle in Honduras. The additional dietary treatments used in this study were dried distillers grains (DDG), palm kernel meal (PKM), sugar cane (SC), soybean meal and corn (SBMC), and sorghum (SORG). Data were analyzed using PROC GLIMMIX procedure in SAS (version 9.3, SAS Inst. Inc., Cary, NC) to a significance level of ($P < 0.05$).

Bos indicus crossbred cattle were utilized, and harvest yield data (n = 240), carcass quality data (n = 230), and fabrication yield data (n = 142) were collected from each of the treatments.

GF had the lowest values for CIELAB (Commision Internationale de I'Eclairage, L*, a*, b*) color values and pH ($P < 0.01$). GF possessed the oldest lean maturity, lowest marbling score, darkest colored lean, yellowest fat color, lowest muscle score and coarsest textured lean ($P < 0.01$).

The SBMC treatment was the heaviest ($P < 0.01$) throughout all finishing programs, dominating in live weight (LW), hot carcass weight (HCW), cold carcass weight (CCW), and red meat yield (RMY). Additionally, SBMC was also the most valuable ($P < 0.01$) in terms of carcass value (CV) and total value at 1494.01 (US$). However, SBMC was the most expensive ($P < 0.01$) for the packer, at the purchase price of 1234.05 (US$). Total profit was significant ($P < 0.01$) for all treatments, with SBMC the most profitable for the packer at 259.96 (US$). GF was lightest and least valuable throughout every observation ($P < 0.01$), excluding red meat yield percentage of CCW (%RMY/CCW).

Evidence presented in this study leads us to the conclusion that GF treatment is the lowest yielding and therefore least valuable finishing program. The GF treatment was also the worst quality treatment. Additionally, the SBMC treatment was significantly heaviest and most valuable, being the most monetarily valuable to the packer. Overall there were ($P < 0.01$) differences in RMY for all treatments. However, there were no differences in %RMY/CCW ($P = 0.17$). With increases in energy and protein within the diet, there was a significant increase in weight, therefore an increase in RMY, CCW, and overall CV. Every formulated finishing program was considerably more valuable and higher yielding than GF, and would result in a superior monetary product for the producer, packer, and consumer. RMY was highly influenced by weight. Consequently, CV of the treatments was highly influenced by weight. Overall, any treatment compared to GF increased weight, therefore increasing monetary profit for the processor and producer.

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CHAPTER 1

INTRODUCTION

Historically, Honduras has been the least literate, least urban, and least industrialized country in Central America (Ruhl, 1984). Currently, Honduras is not one of the least developed countries, as classified by the United Nations (2016), but is currently ranked as the second poorest country in Central America, with an unequal distribution of income and high unemployment rate (CIA, 2016). Consequently, management practices to date for the livestock industry in Honduras are considerably lacking and outdated in terms of the global industry. As mentioned in a report released by the Council for Agricultural Science and Technology (CAST, 2013), livestock production is important in developing countries, being a major factor in income, production and overall health (Smith et al., 2012). High quality protein in these developing countries is generally hard to acquire, leading to possible malnutrition and generally lower health overall.

Cattle production in Honduras usually takes place in dual-purpose production systems (dairy and beef products), and most of the profit in these systems is gained through the sale of weaned calves (Schoonhoven et al., 2006) from small and medium sized operations (Sunderlin and Rodriguez, 1996; Humphries, 1998). The prevalence of these dual production systems and *Bos indicus* crossbred cattle lowers milk production, and this cross preference suggests that the producers prefer the vigor of the crossbreeds and the possible income of young steer offspring. Cattle prices in 1994 resulted in an additional income of about 200 (US$) per animal sold, a generally higher amount than the regular income for other primarily grains-producing households (Humphries, 1998).

Honduras is considered to have an agrarian structure (Ruhl, 1984). After 1949, in the post World War II period, there was a large growth of commercial agriculture; the Honduran government began to supply support by spending heavily on transportation and infrastructure, agricultural credit, and technical assistance, in turn stimulating the production of agricultural products, such as beef, cotton, and coffee (Ruhl, 1984). Subsequently, the cattle population on larger farms increased by two-thirds, from 431,076 head to 719,290 in total head between 1952 and 1965 (Frassinetti, 1972), as the amount of pastureland increased to allow the habitation of this larger population. Ranching and palm oil production slowly shifted the labor away from banana production in the lowlands of Honduras (Humphries, 1998). There was a growth in cattle numbers from 1,146,801 to 2,077,459 (81%) from 1952 to 1993 nationwide (Sunderlin and Rodriguez, 1996). Beef production continued to increase throughout the '60s and '70s, growing 37% (Slutsky, 1979). This “cattle boom” is explained through Central America's contribution to the United States’ increased appetite for beef, a 50% growth in consumption from 1960 to 1976 (Sunderlin and Rodriguez, 1996). Inflation caused the US to import low cost beef, which Central America could easily provide. Beginning in 1961 the exportation of Honduran beef rose from 16% to 51% (Sunderlin and Rodriguez, 1996). However, a drop followed this boom, with beef receding from third to seventh place as a foreign exchange earner (Sunderlin and Rodriguez, 1996). Beef exports were an important factor in Honduran livestock growth, but most consumption of Honduran beef began to take place locally. Domestic consumption accounted for 73% of the Honduran beef economy from 1989 to 1992 (Sunderlin and Rodriguez, 1996). However, according to Agrochart (Domestic Consumption / Meat, Beef and Veal / Honduras / Meat / USDA Report /

AgroChart), there has been an 11.11% drop in domestic consumption of meat, beef and veal in Honduras since the 2013/2014 season, with a 42.85% increase in exports. The purpose of this study was to examine the possibility of increased red meat yield and carcass and subprimal value of a restricted product in Honduras: beef cattle.

CHAPTER 2

LITERATURE REVIEW

History of the US Grading System

The United States' Agricultural Service formulated standards for beef grading in 1916 (USDA, 1997). The purpose of the standards was to provide a uniform measurement of carcass characteristics and value much needed by the industry (Harris et al.). Since then, the standards have developed and changed to include new discoveries needed for accuracy of the carcass values. Published first in 1923, slight changes were included in Department Bulletin No. 1246, "Market Classes in Grades of Dressed Beef" which was published in 1924 (USDA, 1997).

Mostly developed for meat market reporting, the standards were also implemented during World War I to select meat suitable for the army, navy, and allied European countries (USDA, 1997). Soon after, the USDA grading standards were also used for selection of meat for steamship lines, restaurants, hotels, dining cars, and hospitals. In June 1926, the standards were formally adopted by the Secretary of Agriculture as the Official United States Standards for the Grades of Carcass Beef and published in Service and Regulator Announcements No. 99 and were the foundation for the voluntary beef grading and stamping service when it was put into practice in May 1927. Official Standards were amended in 1939 to provide a single standard for steers, heifers, and cows because of similar quality traits. This amendment also changed the grade terms "Medium," "Common," and "Low Cutter," to "Commercial," "Utility," and "Canner," respectively. Another amendment in November 1941 formally included the grade terminology for all beef: Prime, Choice, Good, Commercial, Utility, Cutter, and

Canner. Due to research comparing young bull and steer palatability traits, with young bulls varying the most in palatability, the class of “bullock” was introduced as a sexless class designation. The class of “bull” was kept to identify more mature bulls. In October 1980, another amendment was made that included a 10-minute minimum “bloom time” between ribbing and quality evaluation to provide a more accurate and uniform measurement throughout the industry. In November 1987, revisions were made to change the name of the U.S. “Good” class to U.S. “Select,” as “Good” was identified as a deterrent for most consumers in the industry. In April 1989, standards were revised to allow official grading to include quality only, yield grade only, or a combination of the two. This allowed the customer to make a more specific choice in terms of quality and trimness (USDA, 1997).

In January 1997, official standards were amended to only allow maturity A to be included in the Select grade of beef and raised the marbling minimum to modest throughout B maturity. All changes since the implementation of these standards were to increase uniformity and homogenous evaluation throughout the industry (USDA, 1997).

Determining factors of yield grade.

Yield grades are used to measure cutability of carcasses and estimate the amount of saleable beef (Abraham et al., 1980). Cutability is the percentage of closely trimmed retail cuts. Yield grade is determined by four factors: 1) the amount of kidney, pelvic, and heart fat, 2) amount of external fat, 3) area of the ribeye muscle (in^2), and 4) the carcass weight (USDA, 1997). Kidney, pelvic, and heart fat (KPH) includes the kidney and surrounding fat, the lumbar and pelvic fat in the loin and round, and the heart fat in the forequarter. Kidney, pelvic, and heart fat is determined as a percentage of the carcass weight. As this percentage of KPH increases, the amount of closely trimmed retail cuts decreases. The amount of external fat is evaluated perpendicular to the *Longissimus dorsi* and three-quarters up the length of the ribeye from the chine. This measurement can be adjusted according to fat cover throughout the rest of the carcass. The ribeye area (REA) is evaluated by measuring the area of the *Longissimus dorsi* exposed by ribbing at the 12th rib. A grid is used with segments measuring a tenth of an inch: a larger area increases the amount of retail cuts. Hot carcass weight (HCW, lb) is evaluated after the harvesting process. The yield equation is as follows:

$$2.50 + (2.50 \times \text{adjusted fat thickness, inches}) + (0.20 \times \text{KPH}) + (0.0038 \times \text{HCW}) - (0.32 \times \text{REA})$$

Five yield grades currently exist: 1, 2, 3, 4, and 5. Yield grade 1 indicates the highest amount of saleable beef, while Yield grade 5 signifies the least. As yield grade increases, the percentage of boneless closely trimmed retail cuts will decrease (USDA, 1997).

True Animal Value

Many expenses present themselves with livestock production, including feeding, health care, labor, and time. Historically, producers have regained the money spent by increasing the weight of calves sold to the packer. However, more recently the producer is strongly influenced by the demands of the industry, and choices of production are made accordingly. The present review will discuss three factors: live value, beef quality, and drop value. All of these factors determine the overall value of the animal. Producers themselves tend to hold yield in a higher regard than consumers, who usually look at quality when purchasing. A greater amount of saleable beef increases profitability of a carcass substantially, and can offset the expenses involved in the raising of cattle.

Live value.

Live animal value is influenced by many things: breed type, color, absence of horns, gender, body condition and even appearance or absence of implants, to mention a few. Live value is a crucial trait to consider when identifying true animal value. A large amount of live value today in the U.S. is determined by grid-pricing systems. These grids can either be based on quality or yield, and the value yielded by a select group of cattle can be dependent on which grid is used. As described by Tatum et al. (2006), both grids consist of mainly the same components: 1) a base carcass price, 2) quality grade base defined as the percentage of carcasses grading Choice or greater, and used to develop premiums paid for Choice and discounts paid for Select carcasses, 3) Choice-Select spread, and 4) premiums and discounts. The quality grid usually provides incentive for the production of higher quality carcasses. The yield-based grid provides greater yield grade premiums for Select, YG 1 and YG 2 carcasses, which usually compensates for the Choice-Select spread, when the spread is small (Tatum et al., 2006). However, Honduras processing plants purchase cattle on a carcass weight basis.

Beef quality.

Quality grades are widely accepted by the feeding industry, and have a heavy influence on selection and most management practices. Quality grade is determined by combining marbling and maturity of the carcass. Maturity of the carcass (separated into five classes: A, B, C, D, and E) is determined by ossification of the vertebrae (mostly determined by the thoracic buttons), rib color, beef color, firmness and texture of the meat (USDA, 1997).

To assign a numeric value for color, a colorimeter is used. A colorimeter is an instrument that can measure color as the eye measures it (X-Rite, 2007). Colorimeters are tristimulus devices that use red, green, and blue filters to emulate the response of the human eye to light and color. The CIE, or Commision Internationale de I'Eclairage (International Commission on Illumination), is responsible for international recommendations for photometry and colorimetry. In 1931, the CIE standardized color order systems to derive values for describing color. The color system CIELAB (1976) is based on opponent colors theory of color vision, which states that two colors cannot be both green and red at the same time. When expressed in this color system, L* defines lightness, a* denotes red and green, while b* defines yellow and blue (X-Rite, 2007). Hue and Chroma values are also a factor that affects consumer perception. Chroma is the the quality of a colors purity, intensity, or saturation. Low Chroma colors are more neutral, or gray colored. Hue is the common distinction between colors positioned around a color wheel. Hue starts at the positive a* axis of the color wheel and progresses in a counter clockwise direction towards purple (X-Rite, 2007).

The decline of pH has a significant effect on color and eating quality of meat. In living muscle, pH is at an average of 7.2 (Dikeman and Devine, 2014). With the storage of glycogen in the muscle, postmortem anaerobic breakdown of glycogen results in an increase concentration of lactic acid. This increased concentration results in a lower pH and a change of muscle color, from purple to bright red. Many things can influence pH decline. Stress, for example, causes the use of glycogen before immobilization, leaving a depleted amount for post mortem glycolysis. This causes the pH to not decline as much as ideal, resulting in a high pH meat around 6.2. A higher pH results in a darker meat color (dark cutter), which is a negative influence on consumer perception. A higher pH also results in a higher water holding capacity, influencing the ability of the meat to retain water during cutting or application of other external forces. However, there is no perceivable difference in palatability (Dikeman and Devine, 2014).

Juiciness, tenderness and flavor are the traits mostly associated with beef palatability and have been shown to increase with an increase in carcass quality (Blumer, 1963; Pearson, 1966; McBee and Wiles, 1967; Jr, 1974; Smith et al., 1985; Smith et al., 1987). Jeremiah et al. (1970) established that intramuscular fat affects juiciness and flavor directly, while indirectly impacting tenderness and accounting for 12-14% of the variation in palatability. USDA quality grades are used as indicators in cooked beef palatability, and higher marbling is highly sought after. Prior research has concluded that loin and round steaks from higher grading carcasses were on average more palatable than steaks from carcasses of a lower grade (Smith et al., 1987). Additionally, Corbin et al. (2015) found that overall liking by consumers increased with increasing percentage of fat. This same study also established that the higher fat content of the steaks, the more tender they were rated by the consumer, along with a similar trend observed for flavor and juiciness. The same was concluded by O'Quinn et al. (2012) where overall liking also increased with increasing fat percentage, while overall liking was also correlated with consumer tenderness, juiciness ratings, and most highly correlated with flavor liking. In a study conducted by Seggern et al. (2005), variation was observed between 39 muscle cuts from the chuck and round, and observations were made that quality grade most often had an influence onphysical and chemical characteristics of each cut. Legako et al. (2016) found that overall flavor and liking was greater for Prime and Low Choice when compared to Standard. However, Wheeler et al. (1994) established that marbling accounted for no more than 5-10% of the variation in palatability, and within each marbling score was a large range in tenderness. This allows the assumption that there could be a range of tough and tender meat in each marbling score. Smith et al. (1987) established that shear force values were less variable for loin steaks from Prime, Choice and Good(Select) versus Standard, Commercial, Utility and Cutter/Canner. It was also shown that within quality grades, maturity contributed up to 43.1% of variation in overall palatability for top loin steaks (Smith et al., 1987).

Beef quality is influenced by many factors, including diet, breed type, and gender. A cattle diet in Honduras is generally grass fed and rural, not relative to the United States custom of feeding beef. In a study conducted by Nuernberg et al. (2005) grass fed cattle were required to be fed longer to reach the same body weight (620 kg) as grain fed beef, resulting in a significantly older animal and higher maturity, as well as a much higher pH, higher shear force and darker muscle color. The grass fed beef in this study also had a much higher score for fishy tasting beef, possibly related to the higher amounts of long chain Ω-3 polyunsaturated fatty acids; this was also concluded by Daley et al. (2010). Overall consumer acceptability was higher for concentrate-fed beef (Nuernberg et al., 2005; Daley et al., 2010).

The biological type in Honduras is predominately *Bos indicus*, typically crossed with dairy type for the dual-purpose production systems implemented by Hondurans (Humphries, 1998). The largest issue facing *Bos indicus* type cattle is tenderness. During post mortem aging, proteolytic activity inside the muscle breaks down muscle components for more tender meat (Koohmaraie, 1994). The enzymes involved in proteolysis, called calpains (μ- and m- types), are regulated by calpastatin (Koohmaraie and Geesink, 2006). In *Bos indicus* breeds, the prevalence of calpastatin is much higher within the muscle during aging (Shackelford et al. 1991; Whipple et al., 1990). Calpastatin levels 24 hr. postmortem are highly correlated with beef tenderness (Shackelford et al., 1991; Whipple et al., 1990). Tenderness has been shown to have the biggest impact on eating quality for the consumer (Miller et al., 1995; Miller et al., 2001)

Bos indicus cattle also generally grade lower than the typical continental breeds (McKenna et al., 2002). Damon et al. (1960) stated that Brahman sired crosses averaged low Select, and both Young et al. (1978) and Koch et al. (1982) revealed higher marbling scores in Angus crosses than Brahman cattle.

Most of the cattle observed in Honduras were bulls, which is consistent with previous data (Méndez et al., 2009) from the region north of Central America (Mexico). A proposed reason for the high bull population is that the Mexican population preferred low-fat beef. Bulls are also higher yielding and have a higher feed to gain ratio, requiring less money and resources. Along with a low supply of cereal grains in Central America, the reasons for this selection of gender become more apparent (Méndez et al., 2009).

Drop value.

Drop value is determined by the amount and quality of by-products of an animal carcass, and reflects the wholesale price that packers receive from the animals by-products that "drop" off an animals carcass when it is dressed, on a dollar per hundred weight basis (Marti et al., 2011). Some fat and bone remains on the carcass and is added to the volume of offal. Currently the hide is the most valuable component of the drop value for a beef animal, accounting for an average of about 75% of the overall offal value (Marti et al., 2011). Almost all offal from a beef carcass has a value on the current market. Offal includes edible components (entrails and internal organs of the animal), inedible components (hide and skin, hair, horns, teeth, fats, bone, ligaments and cartilage, feet, glands, blood and lungs), and tallow. Rendering is the process of heating animal tissues and skimming off the oils and fats. These rendered products are generally sold as inputs into further products such as cosmetics, soap, and leather. By-products and tallow account for 10 and 20% of the live value, respectively (Marti et al., 2011). The United States Department of Agriculture (Marti et al., 2011) states that offal makes up about 44% of the live weight of cattle. Prices for offal have recently increased, mostly due to an increased demand in Asia and other foreign countries. By-products also account for more than 23% of the volume for beef/veal exports from the U.S. (Marti et al., 2011). The resulting inedible by-products including blood and bone meal are rich in protein and are valuable for the feeding of other species. However, it is restricted for use in ruminants, with the most high risk materials being unavailable for feeding, to prevent the occurrence of bovine spongiform encephalopathy (Bovine Spongiform Encephalopathy - Feed Ban Enhancement: Implementation Questions and Answers; Mathews et al., 2006; Mathews, 2008).

Carcass Value

Quality grade, yield grade and biological type all effect carcass value. Overall, biological type is the most important factor that determines what quality grade and yield grade will be. *Bos indicus* breed types are much different from *Bos taurus*, and consequently have very different palatability traits. *Bos indicus* cattle have repeatedly been shown to have increased levels of calpastatin activity over *Bos taurus*, which decreases postmortem tenderization resulting in tougher beef (Dikeman and Devine, 2014). Additionally, in determination of value, *Bos indicus* prevents eligibility for many premiums and branded programs at the processor, while other types (dairy) can result in discounts.

Carcass components.

An animal with the absence of offal (removal of hide, head, viscera, etc.) is the dressed carcass (Dressing Percentage of Slaughter Cattle). The carcass is comprised of three constituents: muscle, bone and fat. Muscle is the most important, being the foremost factor in overall carcass value in terms of boneless closely trimmed retail cuts (USDA, 1997). Fat is the second most important, being the major influence in the determination of quality for the carcass. Increased quality from deposition of fat within the muscle increases carcass value substantially. Bone inclusion in the carcass is unavoidable, as it is the framework for the whole carcass. Most of the bone will be removed and designated to the offal (Marti et al., 2011).

Muscle.

The muscle is the most valuable constituent of the carcass, and the most valuable cuts originate from the rib and loin. In 2005, a study was conducted assessing findings of the CattleFax organization; A trend was discovered revealing that between 1993 and 1998 the wholesale values of the rib and loin increased by 3-5%, while wholesale cuts of the chuck, round, and trimmings had dropped by 25-26% (Seggern et al., 2005) and this was startling to the beef industry, showing an enormous loss of value from the carcass.

With this discovery, the initiative to discover the potential value of these muscles was implemented. The mentioned study was conducted to establish the actual characteristics of the under utilized muscles from the chuck and round. The characteristics studied for each muscle were color, expressible moisture, emulsion capacity, pH, proximate composition, collagen content, pigment and heme-iron content, and WBSF. With the results discussed within the study conducted by Seggern et al. (2005), muscles can now be sorted for value added cuts depending on the respective characteristics determined for each muscle.

Bone.

Bone is the support structure for the animal. It provides the infrastructure for attachment of muscle, tendons and ligaments and protects the vital organs. Bone has been shown to comprise 11-18.6% of carcass composition (Preston, Vance, Cahill, & Kock, 1974). The large percentage of bone weight decreases percentage of boneless closely trimmed retail cuts, which are the main constituent of carcass value, as the value system used by packers and feedlots is on a per hundred weight basis. During fabrication, the majority of bones are removed from the carcass and become part of the drop value of the animal.

Fat.

Marbling is the most important factor in carcass quality. However, the pursuit of higher marbling can lead to decreased yield and fatter carcasses (Wheeler et al., 1994). Genetics have shifted in the past 20 years, resulting in the possibility of a higher marbling degree without over-finishing the animal (NAMP, 2007). Multiple aspects influence fat deposition in the body: breed, diet, and environmental factors (such as stress) are all involved. There are four major depots of fat, which are increased in order over the life of the animal. 1) internal fat (KPH on the carcass), 2) intermuscular fat (seam fat), 3) subcutaneous fat (back fat), and 4) intramuscular fat (marbling) are the categories, with fat deposition happening in that order, respectively. A minor fat deposit is mesenteric, which is present from the birth of the animal throughout their life. Intramuscular fat deposition relies heavily on diet after accretion of protein is complete. Extra energy intake is stored in lipid vacuoles in these areas as triacylglycerols, and is later used for energy if adequate energy for metabolism is not ingested, and metabolized in the opposite order of deposition (Annison, 1993).

Factors Affecting Red Meat Yield

Gender.

Gender has a large impact on red meat yield. Heifers tend to accumulate more fat in the udder, more mesenteric fat, and more fat on the carcass than steers or bulls do (Dikeman and Devine, 2014). In similar circumstances and weights, steers tend to have more abdominal and KPH fat. Testosterone from males reduces fat synthesis and deposition, while estrogen in females enhances fat synthesis and deposition (Dikeman and Devine, 2014). The greater amount of fat deposition in animals, the less cutability and boneless closely trimmed retail cuts the carcass will contain (USDA, 1997). Jones et al. (1984) concluded that bulls were 8% heavier than steers at a similar back fat depth (6 mm). It was also established that there were higher dressing percentages in bulls when warm carcass weights were compared to empty body weight and expressed as a proportion. Bulls were shown to have a much higher proportion of hot carcass weight and a lower proportion of non-carcass weight than steers. With an average body weight of

400 kg for steers, bulls had an additional 4.0 kg of carcass weight (Jones et al., 1984). However, it has been established that bulls fatten at a heavier weight than steers (Berg and Butterfield, 1976), so consequently these animals were older at slaughter.

Breed type.

Leaner breeds generally tend to have greater carcass yield, while higher marbling breeds generally are lower in product yield (Beef Cattle Breeds and Biological Types | Publications and Educational Resources | Virginia Tech). Dairy type breeds are some of the highest marbling breeds, but they are also the lightest muscled. In a study conducted by Paschal et al. (1995), they established that *Bos indicus* cross calves were faster gaining and growing post-weaning than Angus crosses, and Grey and Red Brahman cattle were the heaviest out of all different cross breeds of *Bos indicus* cattle. Also, the Red and Grey crosses were the heaviest carcasses in the study compared to other Zebu crosses and one Angus cross. Also, Brahman cattle have been shown to have lower quality attributes than their *Bos Taurus* counterparts (Butler and Reddish, 1956; Damon and Crown, 1960; Koch et al., 1982; Cundiff et al., 1993).

Diet.

The humid tropics are considered the richest regions in the world for growing crops and animal production. However, these regions are behind in terms of intensive animal production. The most prominent factor in the lack of intensive practices are the scarcity of cereal grains and the fact that fast growing tropical grasses are very low and diluted in terms of nutritional value (Leng and Preston, 1976).

Diet is a very important factor in terms of growth. By-products from the grain processing industries generally constitute 5-60% of the finishing diet in the US (Dikeman and Devine, 2014). After being fed a grain based diet, both number and size of adipocytes within the muscle has shown to increase substantially. In a high cereal grain diet, animals must be adapted at an inclusion rate increasing by 5% grain per week until they reach a 85-95% grain ration on dry matter basis to completely utilize all the muscle growth and fat deposition possibilities. Higher concentrate diets have been shown repeatedly to increase growth in terms of muscle and marbling. All constituents of the diet contribute to the growth of the animal, with energy being derived through the ruminant metabolism and breakdown of nutrients in the rumen. Ruminants have the unique ability to metabolize almost any diet constituent due to the microbes living within the digestive tract. This allows for more utilization of feedstuffs. Also, when microbes die or are passed into the rumen, they can be utilized by the ruminant animal as microbial protein (Dikeman and Devine, 2014).

Harrison et al. (1978) showed that a longer feeding period increased carcass weight, fat thickness, REA, internal fat, lowered yield and reduced cooler shrinkage. Harrison et al. (1978) also demonstrated that increasing length of feeding and nutritional plane enhanced quality characteristics, especially those fed a higher grain diet or a ration for 98 days. Furthermore, it was revealed that grass fed (winter growing ration followed by summer grazing) cattle had the lightest carcasses; while short- (same as grass fed followed by 49 days on a high grain ration), long- (same as short-fed but 98 days), and forage- (same as grass-fed followed by 98 days on a high forage diet) fed diet animals had the heaviest carcass weights (Harrison et al., 1978).

Poultry litter.

Non-protein nitrogen is very important to the health of the microbes within the rumen, providing more than 70% of the ruminant's energy supply. The microbes can utilize this source of nitrogen, and then produce volatile fatty acids as an energy source for the animal (Erwin et al., 1961; Bergman, 1990). Sources of non-protein nitrogen can vary. One source utilized in the feeding of the cattle from Honduras includes poultry litter. Belasco (1954) established that uric acid, the primary excretory product from chickens, is able to be utilized by rumen microorganisms. Poultry litter is commonly used as a source of cheap nitrogen in multiple countries, including Malaysia, Honduras and others (Silanikove, 2000). Poultry litter provided to beef cows supplied the necessary nutritional requirements for maintenance and early pregnancy (Silanikove et al., 1987). However, it has also been shown that over consumption of poultry litter can cause serious liver damage (Silanikove and Tiomkin, 1992).

During a trial conducted by Noland et al. (1955), twenty beef steers were on a diet containing cottonseed meal or poultry litter. The authors reported that even though the poultry litter groups gained 92% as much gained by their counterparts fed cottonseed meal, it required 24% more of the concentrate mix and hay to produce 100 lb. of gain. No abnormal digestive problems or refusals of feed were reported. There have been concerns in the U.S. about litter from confined chickens, who are more susceptible to contracting pathogenic bacteria, especially chicks. In a study conducted in Georgia, it was determined that poultry litter fed to cattle was not a source of harmful pathogenic bacteria (Martin and McCann, 1998). Current U.S. practices currently do not inhibit feeding of poultry litter to beef animals. However, there are certain consumer acceptability issues associated with the feeding of poultry litter (G2077 Feeding Poultry Litter to Beef Cattle | University of Missouri Extension). Poultry litter was approved as feedstuff for ruminants again in 2005 due to removal of certain hazardous by-products of the beef animal associated with BSE (G2077 Feeding Poultry Litter to Beef Cattle | University of Missouri Extension).

Sugar cane.

Deepchand (1986) discussed the uses for sugarcane in non-oil producing countries. After the energy crisis in the 1970's in non-oil-producing countries, there was a massive increase in interest for the production of energy from renewable resources. The electricity produced from the burning of sugar cane is the most important by-product of sugar cane for sugar cane producing countries. The steam used from the production of sugar is crucial for the production of electricity, but this also results in an excess of bagasse. Bagasse is the fibrous material remaining after the extraction of sugar from the cane. Pate et al. (1984) stated that it is known that sugar cane fiber (bagasse) has a low digestibility and may have a negative effect on feed intake. Cane tops and leaves (CTL) are also products of sugar cane, and these are also the products of sugar cane not sent to the sugar factory. Cane tops and leaves are made from the immature and growing parts of sugar cane and have a low amount of nitrogen and high crude fiber content. A small amount of CTL is used as animal fodder, while the majority of the rest is used as a fertilizer. As a fodder, it is well known that it has less nutritive value than other roughages. However, it can be a useful alternative during the shortage of other feedstuffs. Current economics indicate that it is feasible to feed sugar cane products in developing tropical countries (Pate et al., 1984).

Interest in sugar cane as an animal feed source began when the Government of Barbados began working with the Canadian International Development Agency (CIDA 1973) on derinding of the plant. Since then however, other studies conducted on sugar cane as a feedstuff have not been as positive as the original study (Donefer et al., 1975). In a study conducted at AREC-Belle Glade, sugar cane was fed in differing levels in feedlot type diets. With increasing percentage of sugar cane in the diet, rate of gain, feed utilization and carcass quality decreased (Pate et al., 1984). Increasing level of sugar cane in the diets also resulted in less dry matter intake and limited the rate of gain (Pate et al., 1984; Gallo et al., 2000; Costa et al., 2005).

The outcome of feeding sugar cane to ruminants is mostly determined by the accompanying supplements. By-pass protein and gluconeogenic precursors are needed for the proper absorption of sugar cane constituents. Protein content in mature sugar cane is negligible, and most of the protein appearing in sugar cane is highly soluble since it is concentrated at the growing point and in the end of the leaves (Preston, 1977). From this it can be ascertained that sugar cane contains very little by-pass protein. Gluconeogenic precursors are derived from two components in the diet: starch, which can escape rumen fermentation (adding to glucose), and through the production of propionic acid. Gluconeogenic precursors are in short supply for sugar cane and since sugar cane does not contain any digestible starch, supplemented protein is normally the limiting factor, and propionic acid is moderate in proportion to total VFAs and low with low supplementation rate (Priego et al., 1977).

The production need of the animal at time of feeding determines how much of these factors are needed. For example, when maintenance of body is low or growth is slow, the need for bypass protein and glucose are minimal, and can usually be produced by rumen fermentation (Preston, 1977). When growth is rapid, additional supplementation of these constituents to the diet are important for the normal growth of the animal.

Voluntary intake or digestibility is also not improved by decreasing particle size. The largest effect was improvement of voluntary consumption with the addition of the sugar cane tops. By the addition of 30% cane tops to the stalk, there was a 15% increase in voluntary consumption (Ferreiro and Preston, 1977). Animal performance is almost entirely influenced by amount of voluntary intake (Preston, 1977). Chopped and derinded sugar cane have been shown to be of equal voluntary intake except when fed with high levels of supplementation (Gonzalez and Williams 1976). Adequate supplemented urea in the diet is instrumental in the efficacy of sugar cane based diets (Leng and Preston, 1976). It has been suggested that the large amounts of protozoa synthesized in the rumen from sugar cane diets does not leave the rumen, so therefore cannot be utilized by the animal. We can conclude from this that protected proteins are essential in sugar cane diets, and are necessary for amino acid and glucose needs for high producing ruminants (Leng and Preston, 1976). If microbial growth falls below requirements, the animal becomes restricted in the requirements for high production. However a recent study has shown that at a level of 8-12 g/kg of calcium hydroxide can increase intake and digestibility of fresh sugar cane (Dias et al., 2011). It has been shown that alkaline agents disrupt and expand the structure of hemicellulose through a process called tumefacient alkaline of cellulose, allowing cellulose molecule expansion and consequently the digestion of hemicellulose, as was the case with the study conducted by Dias et al. (

2011). In a study conducted by Menezes et al. (2011), the addition of calcium oxide to sugar cane silage did not alter performance from unsupplemented silage sugarcane. However, Dias et al. (2011) and other researchers (Corrêa et al., 2003; Neto et al., 2012) recommend increasing the amount of concentrate in the diet to improve digestibility.

Additional studies have also been conducted exploring the options of supplementing lime in sugar cane based diets. Lime increased fiber digestibility, but decreased the average daily gain (Daniel et al., 2013). Additionally, the increased digestibility did not offset the loss of water soluble carbohydrates, which led to an overall lower nutritive value of sugar cane (Daniel et al., 2013).

Palm kernel meal.

Palm kernel meal (also known as palm kernel cake (PKC), solvent-extracted palm kernel meal, and expeller palm kernel meal) is classified as an energy feed. This is because palm kernel meal (PKM) only contains 16-18% protein. However, this amount is sufficient for most ruminants. PKM also has a high fiber content, making it useful as a fiber while also providing protein, energy, minerals and vitamins (Alimon, 2005). Ruminants are more suitable for the feeding of PKM than non-ruminants. Most cattle feed within Malaysia contains a significant amount of PKM, and can sometimes include as much as 70-80% in diets for beef cattle. In Malaysia, feed lot cattle are regularly fed 80% PKC with a live weight gain of 0.6-0.8 kg per day and 1-1.2 kg for crossbred native cattle (Alimon & Mohamed, 2014). Additionally, PKC has been fed at 100% with no negative effects as long as the supply of calcium and vitamins are provided at correct levels, and it has also been shown a 30-50% PKC inclusion in the diet increased performance and live weight gain (Mohamed and Alimon, 2003). In a study performed by Abdullah and Hutagalung (1988), PKC made up 89% of the diet, and resulted in a response very similar to patterns observed with other all concentrate diets. An additional interesting finding was a complete defaunation of the rumen fluid, which has been shown to lead to a significant weight gain in cattle given a high energy diet (Bird and Leng, 2007). Alimon (2005) showed that the digestible energy in PKM is similar to feedstuffs of cereal origin. Additionally, carcass analysis indicated that quality was superior to grass fed or pasture fed cattle (Mohamed and Alimon, 2003) and has also been shown to be very cost effective and manageable for most programs, with a 30% inclusion rate shown to be the most cost efficient, with lowest cost per kilogram of live weight gain (Mohamed and Alimon, 2003).

Recommendations state that PKC should only be fed at ranges from 50-80% for the avoidance of metabolic diseases and digestive disorders (Mohamed and Alimon, 2003). It is also recommended to include 10-15% grass, hay, or other fibrous resources to avoid these disorders. Their additions will also reduce the rate of passage of PKC in the rumen, allowing for more digestion of nutrients for the animal. Results from a study conducted by Abdullah and Hutagalung (1988) revealed that males are superior in terms of dry matter intake, daily gain, and kg dry matter gain as compared to females.

Growth Promotants

Rumen fermentation modifiers, steroid hormones, and beta-adrenergic agonists are all considered growth promotants. Steroid hormones are the focus of growth promotants for this review.

Steroid hormones are natural or synthetically produced estrogens, progestins, and androgens. They increase average daily gain (Johnson et al., 1996a), improve feed efficiency (Johnson et al., 1996a), and improve lean tissue deposition (Anderson, 1991). Steroidal implants include estrogenic implants (female hormone) and androgenic implants (male hormones). Implants on average increase carcass weight 9-35 kg, a typical weight increase of 18-25% (Dikeman and Devine, 2014). Androgenic implants lead to increased satellite cell activity. Satellite cell proliferation is affected by androgenic implants, decreasing the lag phase of proliferation, increasing protein synthesis rate and decreasing protein degradation rate (Johnson et al., 1998).

Estrogenic implants increase the production of growth hormone, or somatotropin. This peptide hormone stimulates cell reproduction, growth and the production of insulin-like growth factor 1 (IGF 1) (Johnson et al., 1996b; Dikeman and Devine, 2014). IGF 1 has been shown to act on nearly every cell in the body, having a major impact on growth. The effects of steroid implantation on palatability have not been considered conclusive. It is recommended that steroids not be used later on in the finishing diet, as it can significantly affect tenderness (Samber et al., 1996; Foutz et al., 1997; Morgan, 1997). There have been interactions shown between steroid dosage and breed type. Negative impacts on tenderness are likely to be observed when multiple doses of androgens are used, but in most situations there are no significant or important effects (Dikeman and Devine, 2014).

Environmental Effects

Stress can have an immense impact on growth. For a conservative average temperature of 30°C and 80% humidity (Weather and Climate: San Pedro Sula, Honduras, average monthly, Rainfall (millimeter), Temperatures (celsius), Humidity, Wind Speed), the heat index provided by the National Weather Service calculates to

37.7°C (99.8°F) (Page and US Department of Commerce) and is considerably higher than a comfortable heat level for ruminants. Conrad (1985) stated that temperatures between 15-25°C allow a normal feed intake, while temperatures above 35°C can decrease feed consumption from 10-35%. Hyperthermia can offset productivity regardless of breed or stage of adaptation (Silanikove, 2000). Heat stress can result in decreased feed intake (Albright and Alliston, 1961; Silanikove, 1992) and have a major impact on growth, while coupled with improper nutrition, can cause a severe deficiency in growth. High feed intake increases metabolic rate, and to maintain ambient body temperature, dietary intake decreases (Blackshaw and Blackshaw, 1994). However, Finch (1984) reported that adapted cattle breeds have a slower rise in core body temperature, which is fortunate for cattle producers in Honduras. Previous data states that *Bos indicus* breeds and their crosses are more capable of handling heat stress than *Bos taurus* breeds. This is due to different characteristics of their species, including metabolic rate, sweating rate, and coat characteristics and color (Blackshaw and Blackshaw, 1994). Blackshaw and Blackshaw (1994) also reported that since *Bos taurus* breeds have a higher heat loading at the skin, they tend to sweat substantially more than *Bos indicus* breeds to maintain core body temperature. Also, Brahman types had a much greater affinity of tolerating and thriving in summer conditions with adequate feed and water available (Blackshaw and Blackshaw, 1994).

CHAPTER 3
Honduran production systems and dietary impacts on beef carcass and offal yields and value

INTRODUCTION

Cattle finishing programs in Honduras are predominately grass. However, with this finishing program, results have consistently been shown to be below standard. With a growing world population and increased need for protein worldwide (CAST, 2013), current management practices and programs need to be revitalized. Overall potential of beef animals and products has been greatly underestimated in Honduras and has been accompanied by low beef yield and value. Many byproducts of other agricultural practices in Honduras are available for different applications and can be applied in the diets to beef cattle. The use of low cost byproducts from other industries not only helps the beef producer but can increase carcass yield and value, and could also be beneficial to the producers of the agricultural byproducts.

With Honduras historically being one of the least industrialized countries in Central America, there is a need to increase production in the global economy. Currently, Honduras is not one of the least developed countries, as classified by the United Nations (2016), but is currently ranked as the second poorest country in Central America, with an unequal distribution of income and high unemployment rate (CIA, 2016). The growth of livestock is important for developing countries such as Honduras, providing a use for otherwise inedible or unusable “waste”. Many industry byproducts are unavailable for further use as foodstuffs, but are available for use in ruminant diets (CAST, 2013). Efficient protein sources in developing countries is often limited, and is where livestock can play a major part in overall health of the population (Smith et al., 2012). The economic value of animals in Honduras is also significant, being a major source of income of up to 200 US dollars above that of regular grain producing households (Humphries, 1998). The objective of this study was to increase yields and value of Honduran beef cattle.

MATERIALS AND METHODS

Cattle background

Bos indicus cross cattle were used for this study. Fabrication data (n = 142), quality data (n = 220), and harvest data (n = 230) were collected. Six different diets were utilized for feeding. Table 1 presents the percentages of each finishing program used in this study. All dietary treatments are shown except for the control grass fed treatment as there were no available samples for processing samples of the grass the animals were grazing. Treatments were formulated on an estimated dry matter basis to a crude protein content of 13.5%. Treatments were named as follows with days on feed (DOF) and initial average weight following, respectively: sugar cane (SC, 165, 305 kg), palm kernel meal (PKM, 108, 352 kg), dried distillers grain (DDG, 118, 327 kg), soybean meal and corn (SBMC, 84, 443 kg), sorghum (SORG, 74, 425 kg), and the control grass-fed only treatment (GF, N/A, N/A). These treatments were named according to specific feedstuffs utilized in each diet. It is worth mentioning that the GF treatment used in this study was at peak performance for that finishing program type, having come out of feeding in the rainy and most productive season (May-October). However, DOF, intake, and initial weight for GF cattle was unknown.

Carcass evaluation

Cattle were loaded and transported from their respective feedlot locations and shipped to the beef processing plant in Siguatepeque, Honduras, CA according to producer preferences. This led to the differing days on feed as seen in the previous section. Treatments were harvested on dates shown (fabricated the following day) and animals per treatment are as follows: PKM (February, 9, 2015; n = 34), SC (April, 7, 2015; n = 38), DDG (November, 18, 2015; n = 38), SBMC (November, 17, 2015; n = 62), SORG (November, 16, 2015; n = 33), and GF (November, 17, 2015; n = 25). Animal identity was transferred to the carcass and was maintained throughout harvest, quality grading and fabrication process. The animal was tagged at hide removal, while offal items were transferred to plastic tubs and tagged with the same tag number.

Harvest data was collected for all cattle included in the study. The harvest weights recorded include live weight (LW), hot carcass weight (HCW), hide, ears, head, lips, horns, head trim, front hooves, hind hooves, skinned tail, switch, liver, kidneys, spleen, penis, testicles, pluck, and kidney, pelvic, and heart fat (KPH). These offal items were transferred to plastic cartons with the same identification number. Honduran processing plant workers were utilized for help with data collection. A scale was certified and balanced with certified weights for use in weighing offal constituents (Mettler-Toledo International Inc., Columbus, OH). Plastic cartons were removed from weight before recording weight of each constituent. Each item was weighed separately.

After a 24-hour carcass chilling period (dry chilling) and a minimum 1 hr bloom time for optimum color appearance, personnel from Texas Tech University evaluated carcass grade data using USDA grading standards (USDA, 1997). Data collected included ribeye area (REA), fat thickness, hump height, CIELAB values (objective), hue (calculated), Chroma (calculated), pH (objective), and subjective measures for skeletal maturity, lean maturity, overall maturity, marbling, color score, texture, firmness, heat ring, dark cutter score, muscle score, and fat color score. Numerical CIELab values were captured with a CR-400 Chroma meter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ). The CR400 Chroma meter was calibrated with a CR-AR3 calibration plate (Konica Minolta Sensing Americas, Inc., Ramsey, NJ). pH was measured with a handheld pH meter prior to fabrication (TPS Model WP-90, TPS Pty Ltd, Brandale, QLD, Australia).

Carcass fabrication data were collected for cattle from each diet trial. The number per treatment are as follows: PKM (34), SC (38), DDG (15), SBMC (15), SORG (15), and GF (25). The number of animals per treatment was determined by processing availability, and the first 15 carcasses were pulled from DDG, SBMC, and SORG treatments due to availability and time allowed by the processor for weighing. Before fabrication, cold carcass weights (CCW) were recorded using a scale certified balanced with certified weights. Carcass constituents were classified according to Institutional Meat Purchase Specifications (IMPS) for fresh beef products, 100 series (USDA, 2010). All fabricated constituents were denuded of all fat. Carcass fabrication data collected included HCW, CCW, ribeye roll (112A), ribs (bone), skirt (121C-D), brisket (118), clod (114), mock tender (116B), tenderloin (189A), strip loin (180), flank (193), flap (185A), top sirloin (181A), knuckle (167), outside round (171B), sirloin cap (184D), inside round (169), eye of round (171C), and shank meat. The weights of eighty-twenty lean, fifty-fifty trim, special trim, pressed trim, red bone (neck bones), white bone, and cartilage were also collected. Trim was sorted based on visual assessment as usual in a beef processing facility. All constituents were weighed on a scale certified with certified weights (Mettler-Toledo International Inc., Columbus, OH). Red meat yield was calculated by adding the weight of all boneless subprimals, lean and trim.

All monetary values were acquired from the Del Corral processing facility for an average for the year of 2015 as a baseline price for each cut, while a baseline of 4.11/kg (US$) was used as purchase price for HCW. Total carcass value was found by combining all item values for all treatments. Profit was determined by combining offal value and carcass value to determine total value, and then subtracted from the purchase price.

Statistical Analysis

All observations were evaluated in SAS by the procedure PROC-GLIMMIX (version 9.3, SAS Inst. Inc., Cary, NC). Individual animal and kill group (sorted by dates) were used as a random effect, while diet was used as a fixed effect. All tables contain the least squares means (LSM) and the standard error (SEM) of the LSM. All analyses were performed using a significance level of ($P < 0.05$). Correlations were calculated using PROC CORR procedure in SAS (version 9.3, SAS Inst. Inc., Cary, NC).

RESULTS & DISCUSSION

Overall yield and value

DOF, initial weight, live weight (LW), dressing percentage (DP), hot carcass weight (HCW), cold carcass weight (CCW), red meat yield (RMY), offal weight, percent offal of live weight (%OFF/LW), percent red meat yield of live weight (%RMY/LW), percent red meat yield of cold carcass weight (%RMY/CCW), carcass value (CV, $/kg), offal value, total value, paid value by the packer, and total profit for each treatment are listed in Table 2.

The initial weight and DOF varied tremendously across all treatments. The comparison that seems to be very significant is the increase in live weight from initial weight. For example, our SBMC treatment was 443 kg while our SORG treatment was 425 kg, only a 20 kg difference. However, our harvest weight for each treatment was 532.5 kg and 467.1 kg, respectively, with only 10 more DOF from SBCM to SORG. This almost 70 kg difference is hard to interpret, and needs to be investigated further. However, all the variation within these treatments could be attributed to diet, weather, genetics, and various other management practices and influences. On the contrary, this supports our conclusion that weight was the major driver behind RMY.

The SBMC finishing program produced heavier animals and consequently heavier carcasses ($P < 0.01$) than all other finishing programs, including LW, HCW, CCW, and RMY. There was no difference in %RMY/CCW between all treatments. However, there was a difference ($P < 0.01$) in RMY on a weight basis, with SBMC being the greatest. This leads to the conclusion that while %RMY/CCW didn't necessarily increase with weight, the RMY was significantly impacted by increase in weight, leading to an increase in monetary value. SBMC was also the heaviest ($P < 0.01$) in offal weight (70.19 kg). Offal weight was least ($P < 0.01$) for the GF treatment. The DKPM program displayed the highest ($P < 0.01$) DP, while both SC and SBMC displayed the highest %RMY/LW ($P < 0.01$). Although SC displayed the highest dressing percentage average carcass weight and RMY calculations were far less than the leading group (SBMC). The SBMC finishing program was also the most valuable in terms of CV (*P* < 0.01).

While SBMC was the highest in total value (*P* < 0.01), it was also the most expensive, costing the packer 1234.05 (US$). However, Table 2 shows the values at a base price of $4.11/kg of HCW for purchasing. This leads to SBMC being the most profitable for the packer at 259.96 (US$), while GF was the least profitable at 164.68 (US$).

Harvest offal evaluation

Differences (*P* < 0.01) were found among treatments for overall offal weight, with SBMC being the heaviest (Table 2). The offal weights and percentages are shown in Table 3 (a&b). Blood and hide values were not included in the offal weights and yields due to minimal weight values. The front feet, hind feet, and head were the heaviest in the DDG, SC, PKM, SBMC, and SORG treatments (*P* < 0.01). The horns were heaviest for SC, GF, and SBMC (*P* < 0.01). The GF treatment was the lowest for skinned tail throughout all treatments (*P* < 0.01). The switch was heaviest for GF, SBMC, and SORG (*P* < 0.01). The spleen was heaviest in the DDG and PKM treatments (*P* < 0.01). The GF treatment was the lowest for pluck weight (*P* < 0.01). The kidneys weighed the most for SC (*P* < 0.01). Head trim was heavier (*P* < 0.01) for DDG, SBMC, and SORG compared to other treatments. The ears and lips were heavier for PKM and SBMC (*P* < 0.01). The SBMC treatment had the heaviest penis (*P* < 0.01). The testicles were heaviest for SBMC and SORG (*P* < 0.01). KPH was heaviest for DDG and SBMC (*P* < 0.01). Overall, the majority of the weights were the heaviest for SBMC and least for GF.

Offal value was significantly impacted by dietary treatment. The three most valuable offal products were the skinned tail, head trim, and testicles ($5.08/kg, $3.62/kg, and $3.31/kg, respectively). Skinned tail generated greater ($P < 0.01$) value for DDG, PKM, and SBMC compared to all other treatments. There was no significant difference ($P = 0.31$) between treatments for head trim. The SBMC treatment was the most valuable ($P < 0.0001$) for testicles. Overall, offal value was reasonably distributed, with DDG, PKM, SBMC, and SORG leading in the most valuable ($P < 0.01$) category, with PKM being the highest at 63.16 (US$). The SC treatment was in the intermediate category ($P < 0.0001$) valued at 59.44 (US$). The GF treatment was significantly least in offal value ($P < 0.0001$) at 49.90 (US$).

Carcass quality

Table 5 displays the pH, CIELAB values, hue and Chroma for all treatments. The GF treatment possessed the lowest L* value, a* value, b* value, and highest pH value ($P < 0.01$), indicating the cut surface was darker, less red, and less yellow than all other treatments. All other finishing programs were significantly lighter colored and possessed a significantly lower pH ($P < 0.01$). Additionally, GF possessed the lowest Chroma and hue values, expressing the least vibrant red and the darkest red color. DDG had the most vibrant color of red ($P < 0.01$) as shown by the high Chroma value. Abril et al. (2001) reported similar results, that as pH increases, values for L*, a*, b*, Chroma and hue decreased. It was also shown that b* was the best indicator of pH between two pH groups (pH<6.1 and pH >6.1). Also, similar to our findings, results have consistently indicated that grass fed lean is generally darker than their concentrate finished counterparts (Schroeder et al., 1980; Bidner et al., 1985; McCaughey and Cliplef, 1996;

Realini et al., 2004). Conclusions were also supported in studies (Immonen et al., 2000a; Immonen et al., 2000b) where bulls were fed a diet of grass silage or a high energy diet shorty before transportation to the processing facility. The high energy diet was shown to protect the animals from severe pre-harvest glycogen depletion, such as heat or transportation stressors, and also resulted in lower, more acceptable pH values (Immonen et al., 2000a; Immonen et al., 2000b).

Treatment impacted skeletal maturity, lean maturity, marbling, color score, texture, firmness, heat ring, dark cutter score, muscle score, adjusted fat thickness, and fat color ($P < 0.05$, Table 6). Neither hump height nor ribeye area were significantly ($P > 0.05$) effected by treatment. GF possessed the oldest lean maturity, lowest marbling score and darkest colored lean ($P < 0.01$). Additionally, the GF control treatment also exhibited the coarsest textured lean, lowest muscle score, and yellowest fat color ($P < 0.05$). Our results are similar to those reported by Bidner et al. (1981) and Nuernberg et al. (2005), where grass fed animals were required to be fed longer to reach the same weight as grain fed beef, which resulted in an older animal with higher maturity, higher pH and darker muscle color. French et al. (2000) however reported no differences in meat color between grain fed and grass fed beef cattle at a similar weight between treatments. Our results also matched previous research of a more yellow fat color in grass finished beef than in grain finished (Schaake et al., 1993; Bennett et al., 1995; Simonne et al., 1996; Schnell et al., 1997; French et al., 2000; Kerth et al., 2007). This can be attributed to an increased amount of carotenoids present in grass than in grain (Tume and Yang, 1996). The DDG finishing program averaged the brightest red colored lean and smoothest texture ($P < 0.01$). The SBMC finishing program displayed the oldest skeletal maturity ($P < 0.01$).

Table 7 displays the Pearson correlation coefficients for pH, CIELAB values, Chroma, and hue. pH was negatively correlated ($P < 0.01$) to L*, a*, b*, Chroma and hue (r = -0.40 to -0.56). This supports conclusions drawn by Abril et al. (2001) that as pH lowers, L*, a*, and b* increase. This supports the conclusion that as pH decreases, hue and Chroma values increase. When Chroma increases, the color becomes more vibrant, or more "red" in the case with beef. Additionally, it was established in the 2001 study that a pH < 6.1 had higher hue values, similar to what was discovered in the current project. Chroma was highly correlated to a* and b* values (r = 0.99 and 0.88, respectively). Hue was most highly correlated with b* values. This leads to the conclusion that when b* values increase, the hue value increases, moving counterclockwise from the a* axis towards and orange hue and away from purple.

Fabrication yields

Fabrication subprimal yield and percentage of CCW (%CCW) for subprimals, trim, and bone are summarized in Tables 8, 9 and 10. Treatment influences ($P < 0.05$) all subprimal weights, excluding mock tender ($P = 0.24$) and flap ($P = 0.97$).

As seen in Table 8, SBMC had heavier ($P < 0.01$) for ribeye roll, skirt, and clod on a weight basis compared to all other treatments. The brisket was heaviest ($P < 0.01$) in the treatments DDG, PKM, SBMC, and SORG. The SBMC treatment was heaviest ($P < 0.01$) for clod. The SBMC treatment was the heaviest subprimal for all significant ($P < 0.01$) categories. GF was the lightest for every subprimal (Table 8) except for skirt, which can possibly be attributed to the major increase in volume of special trim for PKM and SC (16.38 and 15.31, respectively). PKM (0.76) and SC (0.62) produced the lightest subprimal weights for skirt. There were no differences (P = 0.24) in weight for mock tender. No weights were collected for the PKM treatment for mock tender.

Hindquarter subprimal weights can be found in Table 9. The tenderloin was heaviest (P < 0.01) in the DDG, SBMC, and SORG treatments. The DDG, PKM, and SBMC treatments were heavier (P < 0.01) for striploin than all other treatments. GF had lighter (P < 0.05) flank weight compared to SC, PKM, and SBMC, but did not differ from DDG or SORG (P > 0.05). Treatment did not influence flap weight (P = 0.97). Top sirloin was heaviest for DDG, PKM, and SBMC. The SBMC treatment was heaviest (P < 0.01) for knuckle, outside round, inside round, and eye of round. Sirloin cap was heaviest (P < 0.01) for DDG and SBMC. Shank meat was heaviest (P < 0.01) for SBMC and SORG.

Weight and yield of trim and bone are displayed in Table 10. The only insignificant (P = 0.23) non-subprimal item was red bone, for both weight and %CCW (Table 8). The items 80/20 lean and 50/50 trim were heaviest (P < 0.01) for the treatments DDG and SBMC. Special trim was heaviest (P < 0.01) for PKM, possibly due to no weight for mock tender and a low skirt (121C-D) weight. Pressed trim and ribs were heaviest (P < 0.01) for the SBMC treatment. White bone was the heaviest (P < 0.01) for the treatments SC, PKM, SBMC, and SORG. The DDG, PKM, and SBMC treatments were heaviest (P < 0.01) for cartilage. All other treatments were (P < 0.01) heavier than GF, excluding pressed trim and white bone, with the SBMC finishing program being the heaviest in CCW.

Our results are similar to those reported by French et al. (2000) and Nuernberg et al. (2005), where grass fed animals were required to be fed longer to reach the same weight as grain fed beef. Realini et al. (2004) displayed the same results, where concentrate fed animals had a greater carcass weight as compared to a forage finished diet in Uruguayan Hereford steers ($P < 0.05$). Similar to our conclusions, McIntyre and Ryan (1984) concluded that grass fed beef possessed a lower carcass growth rate than grain fed beef.

All yield values as expressed by %CCW for treatments were significant ($P < 0.05$) except for clod ($P = 0.86$), outside round ($P = 0.35$), and red bone ($P = 0.23$). A key point to remember with the %CCW is that they are only a percentage of the overall CCW. Therefore, if they were significantly higher in %CCW, this does not mean they were heavier for that subprimal. Whether or not subprimal weights were large, there was not much variation in %CCW between treatments. Additionally, we see a trend where muscle cuts from the chuck and round made up a large part of overall CCW, such as the clod, knuckle, outside round, and inside round.

Fabrication subprimal and carcass value

Table 11 displays the average forequarter subprimal monetary values and their respective percentage of overall CV. The SBMC treatment was the most valuable ($P < 0.01$) for ribeye roll, ribs, skirt, clod and mock tender. The brisket was the most valuable ($P < 0.01$) for DGG, SBMC, and SORG treatments. The discrepancy in skirt value for GF can possibly be attributed to the major increase in volume (Table 8, 10, 11, & 13) and therefore value of pressed trim for SC and PKM. Ribeye roll was the most valuable subprimal for the forequarter, followed by skirt and mock tender. The ribeye roll was very valuable due to its US$/kg value ($7.91/kg) and weight combined. The skirt and mock tender were valuable ($6.85/kg and $6.85/kg, respectively), however they were very light in weight, resulting in a low contribution to value.

Table 12 displays the average hindquarter cut values for each program and their respective percentage of overall CV. Treatment affected all subprimal values ($P < 0.05$) except for flap ($P = 0.967$) and shank meat ($P = 0.054$). Tenderloin was most valuable ($P < 0.01$) for DDG, PKM, SBMC, and SORG treatments. Striploin was most valuable ($P < 0.01$) for DDG, PKM, and SBMC treatments. The GF treatment was least valuable ($P < 0.05$) for flank, worth significantly less than SC, PKM, and SBMC. Top sirloin was most valuable for DDG, PKM, and SBMC ($P < 0.01$). The SBMC treatment was most valuable ($P < 0.01$) for knuckle, outside round, inside round, and eye of round.

Tenderloin was most valuable US$/kg ($13.19/kg), but was not the largest contribution to hindquarter subprimal value. Inside round, outside round, and shank meat were the highest contributors to hindquarter value due to weight, at $6.65/kg, $6.65/kg, and $5.57/kg, respectively.

Table 13 displays trim values for each treatment and their respective percentage of overall CV. SBMC was most valuable for 80/20 lean, 50/50 trim, and pressed trim ($P < 0.01$). PKM was the most valuable for special trim ($P < 0.01$), but the least valuable for pressed trim along with SC ($P < 0.01$). These abnormal values for PKM and SC can possibly be attributed to differences in sort procedure for trim, lower subprimal weights (such as the aforementioned skirt), or differences in fabrication processes at time of harvest.

The items contributing the most value to the carcass were ribeye roll, ribs, clod, 50/50 trim, and pressed trim. The majority of these items contributed highly to CV due to sheer volume, such as the ribs, clod, 50/50 trim, and pressed trim, while the ribeye roll, being the third most valuable subprimal behind tenderloin ($13.19/kg) and sirloin cap ($8.02/kg), combined both weight and value to contribute to CV.

Conclusion

Evidence presented in this study leads us to the conclusion that GF treatment is the lowest yielding ($P < 0.01$) and therefore least valuable finishing program. The GF treatment was also the worst quality treatment ($P < 0.01$). Additionally, the SBMC treatment was heaviest and most valuable ($P < 0.01$), being the most monetarily valuable to the packer. Overall there were ($P < 0.01$) differences in RMY for all treatments. However, there were no differences in %RMY/CCW ($P < 0.01$). With increases in energy and protein within the diet, there was a significant increase in weight, therefore an increase in RMY, CCW, and overall CV. Every formulated finishing program was considerably more valuable and higher yielding than GF, and would result in a superior monetary product for the producer, packer, and consumer. RMY was highly influenced by weight. Consequently, CV of the treatments was highly influenced by weight. Overall, any treatment compared to GF increased weight, therefore increasing monetary profit for the processor and producer.

Table 1. Ingredient composition (DM basis) of the experimental diets fed in Honduras finishing trials

	Treatment				
Item	SC[1]	PKM[1]	DDG[1]	SBMC[1]	SORG
Ingredient, %					
Fresh Sugar Cane	37.30	--	20.00	15.00	--
Palm Kernel Meal	20.40	30.90	15.00	20.00	17.00
Poultry Litter, dry	19.90	19.90	10.00	8.00	--
Soybean Meal	--	--	--	5.00	8.12
Dried Corn Distillers Grain	--	--	15.00	--	--
Cracked Corn	15.80	40.80	30.00	46.00	--
Ground Grain Sorghum	--	--	--	--	29.86
Ground Corn Cobs	--	--	--	--	20.00
Sorghum Silage	--	--	--	--	15.00
Molasses	6.5	8.40	10.00	5.00	8.00
Calcium Carbonate	--	--	--	1.00	1.00
Monensin 20	--	--	--	--	0.02
Pecutrin Vitamindo	--	--	--	--	1.00

[1]Cattle on these treatments were given free choice mineral supplementation (Nutrivyn Crecimiento)

Table 2. Effect of finishing program on beef whole carcass weight and value of Honduran cattle

	Treatment[1]							
Item	DDG	SC	PKM	GF	SBMC	SORG	SEM[2]	*P*-value
Number of observations	15	38	34	25	15	15		
DOF	118	108	165	-	84	74		
Initial weight	327	305	352	-	443	419		
Live Weight (kg)	468.6[b]	431.4[c]	468.2[b]	384.6[d]	532.5[a]	467.1[b]	10.34	<0.01
Dressing Percentage	55.2[c]	58.0[a]	54.9[c]	51.8[d]	56.6[b]	54.0[c]	0.47	<0.01
Hot Carcass Weight (kg)	259.4[b]	250.2[b]	257.1[b]	199.1[c]	301.2[a]	252.5[b]	6.37	<0.01
Cold Carcass Weight (kg)	259.1[b]	244.3[c]	252.5[bc]	198.7[d]	300.1[a]	251.8[bc]	6.25	<0.01
Red Meat Yield (kg)	179.4[b]	170.1[b]	176.9[b]	137.5[c]	213.8[a]	175.2[b]	4.95	<0.01
Offal Weight (kg)	65.67[b]	60.37[c]	65.42[b]	51.84[d]	70.19[a]	61.32[c]	1.470	<0.01
%Offal/LW[3]	14.1[a]	14.0[a]	14.0[a]	13.5[ab]	13.2[b]	13.2[b]	0.25	<0.01
%RMY/LW[4]	38.1[b]	39.4[a]	37.8[b]	35.8[c]	40.2[a]	37.5[b]	0.53	<0.01
%RMY/CCW[5]	69.1	69.6	70.0	69.2	71.2	69.6	0.64	0.17
Carcass Value (US$)	1208.33[b]	1151.77[b]	1190.31[b]	930.43[c]	1429.07[a]	1178.38[b]	32.170	<0.01
Offal Value (US$)	61.95[ab]	59.44[b]	63.16[a]	49.90[c]	62.93[a]	61.01[ab]	1.200	<0.01
Total Value (US$)	1269.02[b]	1211.21[b]	1253.47[b]	980.33[c]	1494.01[a]	1238.34[b]	33.060	<0.01
Purchase Price[6] (US$)	1062.80[b]	1025.15[b]	1053.31[b]	815.65[c]	1234.05[a]	1034.28[b]	26.090	<0.01
Total Profit (US$)	206.22[b]	186.05[b]	200.16[b]	164.68[c]	259.96[a]	204.06[b]	9.560	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Pooled (largest) SE of LS means.
[3]Offal percentage of live weight; does not include hide, rumen, or blood weight.
[4]Red meat yield percentage of live weight.
[5]Red meat yield percentage of cold carcass weight.
[6]($4.11/kg) of hot carcass weight. Values were supplied by Del Corral, Siguatepeque, Honduras, CA. for an average purchase price of 2015.
[a-e]Values with different letters within a row are significantly different ($P < 0.05$).

Table 3. Effect of finishing program on beef harvest offal or byproduct weights and yield of Honduran cattle (a)

	Treatment[1]							
Item[2]	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	38	38	34	25	62	33		
Front Feet	4.60[ab]	4.45[b]	4.74[a]	4.34[b]	4.81[a]	4.83[a]	0.12	<0.01
%LW[4]	1.01[b]	1.03[b]	1.02[b]	1.14[a]	0.91[c]	1.03[b]	0.03	<0.01
Hind Feet	5.12[abc]	5.05[bc]	5.41[a]	4.80[c]	5.37[ab]	5.49[a]	0.15	<0.01
%LW	1.11[b]	1.17[b]	1.17[b]	1.25[a]	1.01[c]	1.19[ab]	0.03	<0.01
Head[5]	11.37[b]	11.67[b]	11.56[b]	11.76[b]	12.61[a]	12.49[a]	0.26	<0.01
%LW	2.46[c]	2.71[b]	2.49[c]	3.07[a]	2.37[c]	2.69[b]	0.06	<0.01
Horns	0.53[c]	1.08[a]	0.88[b]	1.23[a]	1.17[a]	0.64[c]	0.09	<0.01
%LW	0.11[d]	0.24[b]	0.19[c]	0.32[a]	0.22[bc]	0.12[d]	0.02	<0.01
Skinned Tail	1.58[a]	1.43[ab]	1.59[a]	1.10[b]	1.66[a]	1.48[a]	0.12	<0.01
%LW	0.35	0.34	0.34	0.29	0.32	0.31	0.03	0.74
Switch	0.18[b]	0.14[c]	-	0.19[ab]	0.20[ab]	0.23[a]	0.02	<0.01
%LW	0.04[b]	0.03[b]	-	0.05[a]	0.04[b]	0.05[a]	0.00	<0.01
Liver	5.35[abc]	5.09[bc]	6.11[a]	4.55[c]	6.07[ab]	5.62[ab]	0.38	<0.05
%LW	1.15	1.18	1.31	1.18	1.13	1.22	0.07	0.26
Spleen	1.47[a]	1.05[c]	1.35[a]	0.92[d]	1.19[b]	1.16[bc]	0.06	<0.01
%LW	0.33[a]	0.25[b]	0.30[a]	0.24[b]	0.23[b]	0.25[b]	0.01	<0.01
Pluck	7.42[a]	6.70[ab]	7.64[a]	5.96[b]	7.72[a]	7.34[a]	0.42	<0.05
%LW	1.60	1.55	1.63	1.55	1.45	1.58	0.08	0.18
Kidney	0.90[b]	3.11[a]	0.98[b]	0.78[b]	0.93[b]	0.90[b]	0.20	<0.01
%LW	0.20[b]	0.72[a]	0.21[b]	0.20[b]	0.19[b]	0.20[b]	0.05	<0.01
LW	468.56[b]	431.38[c]	468.18[b]	384.56[d]	532.48[a]	467.04[b]	10.34	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are weights (kg), with percent live weight shown below the weight value.
[3]Pooled (largest) SE of LS means.
[4]Item percentage of live weight.
[5]Tongue included in head weight.
[a-d] Values with different letters within a row are significantly different ($P < 0.05$).

Table 3. Effect of finishing program on beef harvest offal or byproduct weights and yield of Honduran cattle (b)

	Treatment[1]							
Item[2]	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	38	38	34	25	62	33		
Head Trim	1.77[ab]	1.61[bc]	1.64[bc]	1.58[c]	1.84[a]	1.66[abc]	0.07	<0.05
%LW[4]	0.38[ab]	0.37[b]	0.35[b]	0.41[a]	0.35[b]	0.36[b]	0.01	<0.01
Ears	0.73[de]	0.80[cd]	0.95[a]	0.71[e]	0.93[ab]	0.84[bc]	0.04	<0.01
%LW	0.15[c]	0.20[ab]	0.21[a]	0.20[ab]	0.19[b]	0.19[ab]	0.01	<0.01
Lips	0.59[d]	0.72[bc]	0.84[a]	0.74[bc]	0.80[ab]	0.64[cd]	0.04	<0.01
%LW	0.11[d]	0.17[ab]	0.19[ab]	1.20[a]	0.16[bc]	0.13[cd]	0.01	<0.01
Penis	1.10[bc]	1.16[b]	1.03[c]	0.97[c]	1.64[a]	1.05[bc]	0.07	<0.01
%LW	0.25[bc]	0.27[ab]	0.22[c]	0.25[bc]	0.30[a]	0.23[c]	0.02	<0.01
Testicles	0.68[bc]	0.55[c]	0.72[b]	0.74[b]	0.92[a]	0.75[ab]	0.06	<0.01
%LW	0.14[bc]	0.12[c]	0.15[b]	0.19[a]	0.18[ab]	0.16[ab]	0.02	<0.01
KPH	22.28[a]	15.77[c]	20.26[b]	12.03[d]	22.60[a]	17.18[c]	0.78	<0.01
%LW	4.76[a]	3.67[c]	4.34[b]	3.15[d]	4.23[b]	3.69[c]	0.14	<0.01
LW	468.56[b]	431.38[c]	468.18[b]	384.56[d]	532.48[a]	467.04[b]	10.34	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are weights (kg), with percent live weight shown below the weight value.
[3]Pooled (largest) SE of LS means.
[4] Item percentage of live weight (LW).
[a-d] Values with different letters within a row are significantly different ($P < 0.05$).

Table 4. Effect of finishing program on beef harvest offal or byproducts value of Honduran cattle

Item[2] ($/kg)	Treatment[1]							
	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	38	38	34	25	62	33		
Front Feet (1.08/kg)	5.11	4.81	5.11	4.69	5.18	5.23	0.15	0.08
%Offal Value	8.30^{b}	8.11^{b}	8.13^{b}	9.93^{a}	8.26^{b}	8.57^{b}	0.46	<0.05
Hind Feet (1.08/kg)	5.69^{a}	5.45^{ab}	5.84^{a}	5.18^{b}	5.86^{a}	5.90^{a}	0.19	<0.05
%Offal Value	9.26	9.19	9.28	10.99	9.35	9.66	0.54	0.12
Skinned Tail (5.08/kg)	8.30^{a}	7.22^{b}	8.07^{a}	5.60^{c}	8.31^{a}	7.25^{b}	0.25	<0.01
%Offal Value	13.47^{a}	12.17^{bc}	12.78^{ab}	10.91^{d}	13.22^{a}	11.85^{c}	0.35	<0.01
Liver (2.63/kg)	14.72^{b}	13.35^{c}	16.02^{a}	11.93^{d}	15.08^{b}	15.16^{ab}	0.39	<0.01
%Offal Value	23.39^{b}	22.41^{c}	25.33^{a}	23.28^{bc}	23.96^{b}	24.86^{a}	0.41	<0.01
Spleen (0.60/kg)	0.85^{a}	0.62^{bc}	0.80^{ab}	0.55^{c}	0.73^{ab}	0.71^{abc}	0.07	<0.05
%Offal Value	1.37	1.05	1.27	1.07	1.16	1.17	0.09	0.10
Kidney (1.46/kg)	1.32^{bc}	4.53^{a}	1.43^{b}	1.13^{c}	1.31^{bc}	1.36^{bc}	0.09	<0.01
%Offal Value	2.11^{b}	7.64^{a}	2.26^{b}	2.21^{b}	2.09^{b}	2.23^{b}	0.15	<0.01
Head Trim (3.62/kg)	6.25	5.80	5.91	5.71	6.36	6.09	0.27	0.31
%Offal Value	10.09^{b}	9.77^{b}	9.34^{b}	11.96^{a}	10.09^{b}	10.00^{b}	0.52	<0.01
Penis (1.37/kg)	1.59^{b}	1.58^{bc}	1.40^{cd}	1.32^{d}	1.84^{a}	1.47^{bcd}	0.08	<0.01
%Offal Value	2.57^{bc}	2.66^{bc}	2.22^{d}	2.75^{ab}	2.92^{a}	2.41^{cd}	0.13	<0.01
Testicles (3.31/kg)	1.45^{b}	1.82^{c}	2.37^{b}	2.44^{b}	2.91^{a}	2.48^{b}	0.16	<0.01
%Offal Value	3.84^{c}	3.02^{d}	3.75^{c}	4.76^{a}	4.55^{ab}	4.05^{bc}	0.24	<0.01
Pluck[4] (2.14/kg)	15.74^{a}	14.31^{b}	16.32^{a}	12.73^{c}	15.82^{a}	15.91^{a}	0.35	<0.01
%Offal Value	25.40^{ab}	24.06^{c}	25.84^{a}	24.83^{bc}	25.13^{b}	26.11^{a}	0.32	<0.01
Offal Value	61.95^{ab}	59.44^{b}	63.16^{a}	49.90^{c}	62.93^{a}	61.01^{ab}	1.04	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are (US$), with percentage offal value below the item value.
[3]Pooled (largest) SE of LS means.
[4]Includes the heart, lungs, esophagus, and trachea.
[a-d] Values with different letters within a row are significantly different ($P < 0.05$).

Table 5. L*, a*, b*,[1] and pH values for six different finishing programs from Honduran cattle

Item	Treatment[2]							
	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	38	38	34	25	62	33		
L*	36.33[a]	34.84[ab]	33.91[b]	30.12[c]	35.21[ab]	34.10[b]	0.70	<0.01
a*	20.47[a]	18.93[b]	17.69[bc]	16.12[d]	18.31[b]	16.88[cd]	0.54	<0.01
b*	5.49[b]	8.26[a]	5.20[b]	3.10[c]	4.99[b]	4.72[b]	0.36	<0.01
pH	5.87[cd]	5.96[bc]	6.02[b]	6.43[a]	5.84[d]	5.92[bcd]	0.04	<0.01
Chroma	21.24[a]	20.67[a]	18.48[bc]	16.44[d]	18.99[b]	17.53[cd]	0.62	<0.01
Hue	14.39[c]	23.23[a]	15.91[b]	10.46[d]	14.96[bc]	15.38[bc]	0.58	<0.01

[1]L*: 0 = black, 100 = white; positive value = red (a*) or yellow (b*); negative values = green (a*) or blue (b*)
[2]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[3]Pooled (largest) SE of LS means.
[a-d] Values with different letters within each row are significantly different ($P < 0.05$).

Table 6. Effect of finishing program on least square means for beef carcass traits from Honduran cattle

	Treatment[1]							
Trait	DDG	SC	PKM	GF	SBMC	SORG	SEM[2]	*P*-value
Number of observations	38	38	34	25	62	33		
Skeletal Maturity[3]	179.2[c]	236.3[b]	183.8[c]	174.8[c]	274.6[a]	196.7[c]	15.94	<0.01
Lean Maturity[4]	253.4[c]	243.7[c]	315.3[b]	372.4[a]	253.7[c]	272.1[c]	12.66	<0.01
Overall Maturity	221.0[d]	251.6[abc]	245.5[bcd]	272.4[ab]	272.7[a]	241.2[cd]	11.00	<0.01
Marbling[5]	291.8[a]	312.6[a]	295.3[a]	171.6[c]	292.2[a]	254.2[b]	13.32	<0.01
Lean Color[6]	6.5[a]	4.2[bc]	3.7[c]	1.4[d]	4.6[b]	4.0[bc]	0.29	<0.01
Lean Texture[7]	6.6[a]	4.7[c]	4.6[c]	3.2[d]	4.5[c]	5.3[b]	0.27	<0.01
Lean Firmness[8]	6.3[c]	7.1[b]	6.0[c]	7.9[a]	6.1[c]	6.4[c]	0.24	<0.01
Heat Ring[9]	4.3[b]	3.7[c]	4.1[b]	5.0[a]	5.0[a]	5.0[a]	0.11	<0.01
Dark Cutter[10]	4.2[a]	4.0[a]	3.7[a]	1.4[b]	3.9[a]	3.7[a]	0.23	<0.01
Hump Height (cm)	30.2	26.9	32.8	25.7	35.8	26.9	10.41	0.95
Muscle Score[11]	4.0[a]	2.9[b]	3.2[b]	2.2[c]	4.3[a]	4.0[a]	0.17	<0.01
Rib Fat (mm)	5.1	10.1	4.4	0.7	5.2	3.3	2.70	0.19
Adjusted Rib Fat (mm)	5.2[b]	17.8[a]	4.7[b]	0.7[b]	6.5[b]	3.8[b]	3.90	0.04
Ribeye Area, (cm^2)	27.9	30.7	33.8	22.4	28.2	26.7	3.37	0.17
Fat Color[12]	1.5[d]	1.3[d]	1.1[e]	3.1[a]	2.0[c]	2.3[b]	0.10	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Pooled (largest) SE of LS means.
[3,4]100=A[00], 200=B[00], 300=C[00], 400=D[00], 500=E[00].
[5]100=practically devoid[00], 200= traces[00], 300= slight[00], 400= small[00], 500= modest[00].
[6]1=extremely dark; 8= extremely bright red.
[7]1=coarse texture; 8= firm texture.
[8]1= soft; 8= firm.
[9]1= severe; 5= none.
[10]1= full dark cutter; 5= no dark cutter.
[11]1= light muscling; 5= Heavy muscling.
[12]1= Pearly white; 5= dark yellow.
[a-e]Values with different letters within each row are significantly different ($P < 0.05$).

Table 7. Pearson correlation coefficients among colorimeter and pH values of differing Honduran finishing programs

Characteristic	1	2	3	4	5	6
(1) L*	1					
(2) a*	0.69*	1				
(3) b*	0.58*	0.81*	1			
(4) pH	-0.56*	-0.56*	-0.46*	1		
(5) Chroma	0.69*	0.99*	0.88*	-0.55*	1	
(6) Hue	0.45*	0.58*	0.93*	-0.40*	0.66*	1

* Correlation coefficients differ from 0 ($P < 0.01$).

Table 8. Effect of finishing program on beef forequarter subprimal weight and yield of Honduran cattle

	Treatment[1]							
Item[2]	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
Ribeye Roll, 112A[4]	10.16[b]	9.11[c]	10.11[b]	7.23[d]	13.02[a]	10.10[b]	0.35	<0.01
%CCW[5]	3.91[bc]	3.73[cd]	3.99[b]	3.63[d]	4.33[a]	4.01[b]	0.08	<0.01
Skirt, 121C-D	2.11[b]	0.62[e]	0.76[d]	1.70[c]	2.58[a]	2.05[b]	0.07	<0.01
%CCW	0.82[a]	0.25[c]	0.30[b]	0.86[a]	0.86[a]	0.81[a]	0.02	<0.01
Brisket, 118	4.82[a]	4.10[b]	4.75[a]	3.35[c]	5.27[a]	4.81[a]	0.26	<0.01
%CCW	1.83[ab]	1.68[b]	1.87[a]	1.69[b]	1.75[ab]	1.92[a]	0.09	<0.05
Clod, 114	15.96[b]	15.16[b]	15.27[b]	12.44[c]	18.82[a]	15.44[b]	0.69	<0.01
%CCW	6.14	6.20	6.02	6.25	6.26	6.12	0.20	0.86
Mock Tender, 116B	2.29	2.71	-	1.92	2.67	2.29	0.36	0.24
%CCW	1.22	1.10	-	0.80	0.96	0.88	0.14	0.08
Cold Carcass Weight (kg)	259.1[b]	244.3[c]	252.5[bc]	198.7[d]	300.1[a]	251.8[bc]	6.25	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are weights (kg), with percentage cold carcass weight shown below the weight value.
[3]Pooled (largest) SE of LS means.
[4]USDA Institutional Meat Purchasing Specification, Fresh Beef, Series 100 (NAMP, 2007).
[5]Subprimal percentage of cold carcass weight (CCW).
[a-f] Values with different letters within a row are significantly different ($P < 0.05$).

Table 9. Effect of finishing program on beef hindquarter subprimal weight and yield of Honduran cattle

	Treatment[1]							
Cut[2]	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
Tenderloin, 189A[4]	3.30[a]	3.01[b]	3.23[a]	2.47[c]	3.26[a]	3.33[a]	0.10	<0.01
%CCW[5]	1.28[abc]	1.23[c]	1.28[ab]	1.24[bc]	1.09[d]	1.32[a]	0.03	<0.01
Striploin, 180	6.63[a]	6.00[b]	6.37[ab]	4.43[c]	6.70[a]	5.92[b]	0.21	<0.01
%CCW	2.56[a]	2.46[ab]	2.52[a]	2.23[c]	2.23[c]	2.35[bc]	0.06	<0.01
Flank, 193	0.98[ab]	1.00[a]	1.06[a]	0.89[b]	1.06[a]	0.96[ab]	0.05	<0.05
%CCW	0.37[cd]	0.41[bc]	0.42[ab]	0.45[a]	0.35[d]	0.39[bcd]	0.02	<0.01
Flap, 185A	1.80	1.86	1.89	1.85	1.92	1.97	0.14	0.97
%CCW	0.69[b]	0.76[b]	0.75[b]	0.95[a]	0.64[b]	0.78[ab]	0.07	<0.01
Top Sirloin, 181A	6.61[ab]	6.41[b]	6.82[ab]	4.77[c]	7.08[a]	6.36[b]	0.20	<0.01
%CCW	2.56[abc]	2.62[ab]	2.70[a]	2.41[cd]	2.36[d]	2.52[bcd]	0.06	<0.01
Knuckle, 167	8.77[cd]	8.74[d]	9.46[b]	7.67[e]	9.98[a]	9.26[bc]	0.20	<0.01
%CCW	3.45[de]	3.58[cd]	3.75[ab]	3.86[a]	3.33[e]	3.68[bc]	0.06	<0.01
Outside Round, 171B	9.95[b]	9.73[b]	10.02[b]	7.70[c]	11.56[a]	9.86[b]	0.35	<0.01
%CCW	3.80	3.98	3.97	3.86	3.85	3.92	0.08	0.35
Sirloin Cap, 184D	2.40[a]	1.74[c]	1.68[c]	1.63[c]	2.57[a]	2.10[b]	0.08	<0.01
%CCW	0.94[a]	0.71[c]	0.67[c]	0.82[b]	0.86[ab]	0.84[b]	0.03	<0.01
Inside Round, 169	15.76[bc]	15.62[c]	16.70[b]	13.30[d]	18.28[a]	16.67[bc]	0.53	<0.01
%CCW	6.11[c]	6.37[bc]	6.61[ab]	6.73[a]	6.10[c]	6.62[ab]	0.18	<0.05
Eye of Round, 171C	4.43[bc]	4.53[bc]	4.70[b]	3.57[d]	5.09[a]	4.17[c]	0.15	<0.01
%CCW	1.70[b]	1.85[a]	1.87[a]	1.80[a]	1.70[b]	1.65[b]	0.04	<0.01
Shank meat	13.10[bc]	11.93[cd]	12.09[cd]	11.72[d]	15.39[a]	14.08[ab]	0.52	<0.01
%CCW	5.07[bc]	4.88[c]	4.80[c]	5.92[a]	5.12[bc]	5.59[ab]	0.19	<0.01
Cold Carcass Weight (kg)	259.1[b]	244.3[c]	252.5[bc]	198.7[d]	300.1[a]	251.8[bc]	6.25	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are weights (kg), with percent cold carcass weight shown below the weight value.
[3]Pooled (largest) SE of LS means.
[4]USDA Institutional Meat Purchasing Specification, Fresh Beef, Series 100 (NAMP, 2007).
[5]Subprimal percentage of cold carcass weight (CCW).
[a-f]Values with different letters within a row are significantly different ($P < 0.05$).

Table 10. Effect of finishing program on trim and bone yield of Honduran cattle

	Treatment[1]							
Item[2]	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
80/20 lean	10.06[ab]	9.23[bc]	9.72[b]	6.47[d]	11.12[a]	8.24[c]	0.46	<0.01
%CCW[4]	3.84[a]	3.77[a]	3.83[a]	3.25[b]	3.70[a]	3.26[b]	0.13	<0.01
50/50 trim	33.08[ab]	27.34[c]	30.56[b]	18.94[d]	35.58[a]	26.62[c]	1.28	<0.01
%CCW	12.84[a]	11.17[bc]	12.12[a]	9.52[d]	11.87[ab]	10.60[cd]	0.44	<0.01
Special Trim	4.91[de]	15.31[b]	16.38[a]	4.16[e]	9.53[c]	6.27[d]	0.50	<0.01
%CCW	1.83[d]	6.26[a]	6.48[a]	2.08[d]	3.16[b]	2.47[c]	0.15	<0.01
Pressed Trim	22.22[bc]	16.28[d]	15.33[d]	21.29[c]	32.27[a]	24.75[b]	0.96	<0.01
%CCW	8.43[c]	6.66[d]	6.05[e]	10.71[a]	10.75[a]	9.83[b]	0.31	<0.01
Ribs	31.66[b]	26.20[c]	26.75[c]	20.87[d]	34.08[a]	25.94[c]	0.82	<0.01
%CCW	12.25[a]	10.73[c]	10.58[c]	10.50[c]	11.38[b]	10.31[c]	0.19	<0.01
Red Bone	3.90	4.70	4.34	4.16	4.88	4.69	0.49	0.60
%CCW	1.51	1.95	1.72	2.09	1.63	1.86	0.21	0.23
White Bone	38.23[bc]	41.34[a]	40.22[ab]	35.41[c]	40.92[ab]	41.95[a]	1.21	<0.01
%CCW	15.20[cd]	17.00[ab]	16.00[bc]	17.86[a]	13.66[d]	16.71[abc]	0.57	<0.01
Cartilage	3.36[ab]	2.97[b]	3.39[a]	1.87[d]	3.43[a]	2.49[c]	0.18	<0.01
%CCW	1.30[ab]	1.22[ab]	1.34[a]	0.95[d]	1.15[bc]	0.99[cd]	0.07	<0.01
Cold Carcass Weight (kg)	259.1[b]	244.3[c]	252.5[bc]	198.7[d]	300.1[a]	251.8[bc]	6.25	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values are weights (kg), with percent cold carcass weight shown below the weight value.
[3]Pooled (largest) SE of LS means.
[4]Item percentage of cold carcass weight (CCW).
[a-e]Values with different letters within a row are significantly different ($P < 0.05$).

Table 11. Effect of finishing program on beef forequarter subprimal value and percent of carcass value of Honduran cattle

	Treatment[1]							
Item Value[2] ($/kg)	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
Ribeye Roll, 112A[4] (7.91/kg)	80.13[b]	71.80[c]	79.72[b]	57.01[d]	102.64[a]	79.63[b]	2.77	<0.01
%CV[5]	6.62[b]	6.24[c]	6.68[b]	6.12[c]	7.17[a]	6.76[b]	0.13	<0.01
Ribs (4.40/kg)	138.77[b]	114.84[c]	117.23[c]	91.46[d]	149.38[a]	113.70[c]	3.57	<0.01
%CV	11.58[a]	9.98[c]	9.85[c]	9.83[c]	10.49[b]	9.67[c]	0.20	<0.01
Skirt, 121C-D (6.85/kg)	14.40[b]	4.26[e]	5.20[d]	11.60[c]	17.65[a]	13.97[b]	0.46	<0.01
%CV	1.21[a]	0.35[c]	0.44[b]	1.25[a]	1.23[a]	1.19[a]	0.04	<0.01
Brisket, 118 (6.65/kg)	31.94[a]	27.17[b]	31.46[a]	22.24[c]	34.93[a]	31.89[a]	1.73	<0.01
%CV	2.61[ab]	2.36[b]	2.64[a]	2.39[b]	2.44[ab]	2.69[a]	0.11	<0.05
Clod, 114 (5.33/kg)	84.73[b]	80.45[b]	81.03[b]	66.02[c]	99.91[a]	81.95[b]	3.66	<0.01
%CV	6.99	6.98	6.78	7.09	6.98	6.95	0.22	0.83
Mock Tender, 116B (6.85/kg)	15.66[b]	16.10[b]	-	13.13[c]	18.20[a]	15.67[b]	0.60	<0.01
%CV	1.29[b]	1.40[a]	-	1.41[a]	1.27[b]	1.33[ab]	0.04	<0.05
Average CV	1208.33[b]	1151.77[b]	1190.31[b]	930.43[c]	1429.07[a]	1178.38[b]	32.17	<0.01

[1] DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values were obtained from Del Corral, Siguatepeque, CA. The percent of average carcass value (CV) is shown below the value for each cut.
[3]Pooled (largest) SE of LS means.
[4]USDA Institutional Meat Purchasing Specification, Fresh Beef, Series 100 (NAMP, 2007).
[5]Value percentage of carcass value (CV).
[a-e] Values with different letters within a row are significantly different ($P < 0.05$).

Table 12. Effect of finishing program on beef hindquarter subprimal value and percent of carcass value of Honduran cattle

	Treatment[1]							
Item Value[2] ($/kg)	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
Tenderloin, 189A[4] (13.19/kg)	43.42[a]	39.52[b]	42.52[a]	32.49[c]	42.86[a]	43.73[a]	1.28	<0.01
%CV[5]	3.61[ab]	3.44[c]	3.58[ab]	3.49[bc]	3.01[d]	3.72[a]	0.07	<0.01
Striploin, 180 (6.94/kg)	45.88[a]	41.50[b]	44.06[ab]	30.65[c]	46.35[a]	40.92[b]	1.47	<0.01
%CV	3.80[a]	3.61[ab]	3.70[a]	3.29[c]	3.24[c]	3.47[bc]	0.09	<0.01
Flank, 193 (6.65/kg)	6.49[ab]	6.61[a]	7.00[a]	5.90[b]	7.01[a]	6.37[ab]	0.34	<0.05
%CV	0.53[bc]	0.57[b]	0.59[b]	0.63[a]	0.49[c]	0.54[bc]	0.02	<0.01
Flap, 185A (7.91/kg)	14.22	14.70	14.93	14.58	15.18	15.49	1.10	0.97
%CV	1.17[b]	1.27[b]	1.25[b]	1.58[a]	1.06[b]	1.31[b]	0.10	<0.01
Top Sirloin, 181A (6.74/kg)	44.41[ab]	43.06[b]	45.79[ab]	32.01[c]	47.58[a]	42.71[b]	1.35	<0.01
%CV	3.70[ab]	3.74[ab]	3.85[a]	3.44[cd]	3.34[d]	3.62[bc]	0.08	<0.01
Knuckle, 167 (6.65/kg)	58.14[cd]	57.95[d]	62.68[b]	50.82[e]	66.15[a]	61.35[bc]	1.32	<0.01
%CV	4.93[d]	5.04[cd]	5.28[b]	5.48[a]	4.63[e]	5.21[bc]	0.09	<0.01
Outside Round, 171B (6.65/kg)	65.94[b]	64.52[b]	66.46[b]	51.07[c]	76.67[a]	65.40[b]	2.34	<0.01
%CV	5.42	5.60	5.59	5.47	5.37	5.55	0.12	0.43
Sirloin Cap, 184D (8.02/kg)	19.23[a]	13.89[c]	13.45[c]	13.02[c]	20.59[a]	16.82[b]	0.63	<0.01
%CV	1.61[a]	1.21_c	1.13[c]	1.41[b]	1.44[b]	1.43[b]	0.05	<0.01
Inside Round, 169 (6.65/kg)	104.48[bc]	103.54[c]	110.70[b]	88.18[d]	121.19[a]	110.49[bc]	3.50	<0.01
%CV	8.70[c]	8.95[bc]	9.32[ab]	9.51[a]	8.49[c]	9.39[ab]	0.24	<0.01
Eye of Round, 171C (6.65/kg)	29.37[bc]	30.03[bc]	31.18[b]	23.69[d]	33.76[a]	27.68[c]	1.02	<0.01
%CV	2.42[bc]	2.61[a]	2.63[a]	2.55[ab]	2.37[c]	2.34[c]	0.06	<0.01
Shank meat (5.57/kg)	72.70	66.22	67.13	67.79	85.41	78.15	5.20	>0.05
%CV	6.06[bc]	5.76[bc]	5.67[c]	7.31[a]	5.95[bc]	6.64[ab]	0.33	<0.01
Average CV	1208.33[b]	1151.77[b]	1190.31[b]	930.43[c]	1429.07[a]	1178.38[b]	32.17	<0.01

[1] DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values were obtained from Del Corral, Siguatepeque, CA. The percent of average carcass value (CV) is shown below the value for each cut.
[3]Pooled (largest) SE of LS means.
[4]USDA Institutional Meat Purchasing Specification, Fresh Beef, Series 100 (NAMP, 2007).
[5]Value percentage of carcass value (CV).
[a-e] Values with different letters within a row are significantly different ($P < 0.05$).

Table 13. Effect of finishing program on trim values and percent of carcass value of Honduran cattle

Item Value[2] ($/kg)	Treatment[1]							
	DDG	SC	PKM	GF	SBMC	SORG	SEM[3]	*P*-value
Number of observations	15	38	34	25	15	15		
80/20 lean (6.17/kg)	61.86^{ab}	56.72^{bc}	59.75^{b}	39.79^{d}	68.36^{a}	50.66^{c}	2.86	<0.01
%CV[4]	5.06^{a}	4.92^{a}	5.00^{a}	4.26^{b}	4.77^{a}	4.27^{b}	0.16	<0.01
50/50 trim (3.23/kg)	106.40^{ab}	87.93^{c}	98.26^{b}	60.91^{d}	114.42^{a}	85.60^{c}	4.13	<0.01
%CV	8.83^{a}	7.63^{b}	8.28^{a}	6.55^{c}	8.04^{ab}	7.30^{bc}	0.31	<0.01
Special Trim (6.85/kg)	33.54^{de}	104.57^{b}	111.85^{a}	28.43^{e}	65.05^{c}	42.80^{d}	3.40	<0.01
%CV	2.68^{d}	6.08_{a}	9.38^{a}	3.04^{d}	4.53^{b}	3.60^{c}	0.20	<0.01
Pressed Trim (5.57/kg)	123.32^{bc}	90.35^{d}	85.09^{d}	118.15^{c}	179.14^{a}	137.39^{b}	5.32	<0.01
%CV	10.05^{c}	7.84^{d}	7.13^{e}	12.67^{a}	12.52^{ab}	11.66^{b}	0.34	<0.01
Red Bone (3.43/kg)	13.31	16.05	14.81	14.22	16.67	15.99	1.67	0.61
%CV	1.11	1.41	1.25	1.53	1.17	1.36	0.16	0.22
Average CV	1208.33^{b}	1151.77^{b}	1190.31^{b}	930.43^{c}	1429.07^{a}	1178.38^{b}	32.17	<0.01

[1]DDG= dried distillers grains, PKM= palm kernel meal, SC= sugar cane, GF=grass fed control, SBMC= soybean meal and corn, SORG= sorghum.
[2]Values were obtained from Del Corral, Siguatepeque, CA. The percent of average carcass value (CV) is shown below the value for each item.
[3]Pooled (largest) SE of LS means.
[4]Value percentage of carcass value (CV).
[a-e] Values with different letters within a row are significantly different ($P < 0.05$).

REFERENCES

Abdullah, N., and R. I. Hutagalung. 1988. Rumen fermentation, urease activity and performance of cattle given palm kernel cake-based diet. Anim. Feed Sci. Technol. 20:79–86. Available from: http://www.sciencedirect.com/science/article/pii/0377840188901290

Abraham, H. C., C. E. Murphey, H. R. Cross, G. C. Smith, and W. J. Franks. 1980. Factors Affecting Beef Carcass Cutability: an Evaluation of the USDA Yield Grades for Beef. J. Anim. Sci. 50:841–851. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/50/5/JAN0500050841?search-result=1

Abril, M., M. . Campo, A. Önenç, C. Sañudo, P. Albertí, and A. . Negueruela. 2001. Beef colour evolution as a function of ultimate pH. Meat Sci. 58:69–78. Available from: http://www.sciencedirect.com/science/article/pii/S0309174000001339

Agency, C. I. 2016. The World Factbook. Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/ho.html

Albright, J. L., and C. W. Alliston. 1961. Effects of varying the environment upon the performance of dairy cattle. Symp. A Q. J. Mod. Foreign Lit. 32:566–577.

Alimon, a R. 2005. The Nutritive Value of Palm Kernel Cake for Animal Feed. Palm Oil Dev. vol.40 40:12–14.

Anderson, P. T. 1991. Trenbolone acetate as a growth promotant. Compend. Contin. Educ. Pract. Vet. Available from: http://agris.fao.org/agris-search/search.do?recordID=US9150101

Annison, E. F. 1993. Fat deposition in ruminants. In: Fat deposition in ruminants. RAAN. p. 51. Available from: http://livestocklibrary.com.au/handle/1234/19722

Beef Cattle Breeds and Biological Types | Publications and Educational Resources | Virginia Tech. Available from: http://pubs.ext.vt.edu/400/400-803/400-803.html

Belasco, I. J. 1954. New Nitrogen Feed Compounds for Ruminants—A Laboratory Evaluation. J. Anim. Sci. 13:601–610. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/13/3/JAN0130030601?search-result=1

Bennett, L. L., A. C. Hammond, M. J. Williams, W. E. Kunkle, D. D. Johnson, R. L. Preston, and M. F. Miller. 1995. Performance, carcass yield, and carcass quality characteristics of steers finished on rhizoma peanut (Arachis glabrata)-tropical grass pasture or concentrate. J. Anim. Sci. 73:1881–1887. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/73/7/1881

Berg, R. T., and R. M. Butterfield. 1976. New concepts of cattle growth. Available from: http://www.cabdirect.org/abstracts/19760125400.html;jsessionid=335FA54B1A95A571BF805D546A2DDB1C

Bergman, E. N. 1990. Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. Physiol Rev 70:567–590. Available from: http://physrev.physiology.org/content/70/2/567.short

Bidner, T. D., A. R. Schupp, A. B. Mohamad, N. C. Rumore, R. E. Montgomery, C. P. Bagley, and K. W. McMillin. 1985. Acceptability of Beef from Angus-Hereford or Angus-Hereford-Brahman Steers Finished on All-Forage or a High-Energy Diet. J. Anim. Sci. 62:381–387. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/62/2/JAN0620020381

Bidner, T. D., A. R. Schupp, R. E. Montgomery, and J. C. Carpenter. 1981. Acceptability of Beef Finished on All-Forage, Forage-Plus-Grain or High Energy Diets. J. Anim. Sci. 53:1181–1187. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/53/5/JAN0530051181

Bird, S. H., and R. A. Leng. 2007. The effects of defaunation of the rumen on the growth of cattle on low-protein high-energy diets. Br. J. Nutr. 40:163. Available from: http://journals.cambridge.org/abstract_S0007114578000240

Blackshaw, J., and A. Blackshaw. 1994. Heat stress in cattle and the effect of shade on production and behaviour: a review. Aust. J. Exp. Agric. 34:285.

Blumer, T. N. 1963. Relationship of Marbling to the Palatability of Beef. J. Anim. Sci. 22:771–778. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/22/3/JAN0220030771?search-result=1

Bovine Spongiform Encephalopathy - Feed Ban Enhancement: Implementation Questions and Answers. Available from: http://www.fda.gov/AnimalVeterinary/GuidanceComplianceEnforcement/ComplianceEnforcement/BovineSpongiformEncephalopathy/ucm114453.htm#The_2008_Regulation

Butler, O., and R. Reddish. 1956. Factors contributing to the difference in dressing percentage between Hereford and Brahman× Hereford steers. J. Anim. …. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/15/2/JAN0150020523

CAST. 2013. Animal Feed vs. Human Food: Challenges and Opportunities in Sustaining Animal Agriculture Toward 2050. Counc. Agric. Sci. Technol. September:1–16. Available from: http://www.cast-science.org/download.cfm?PublicationID=278268&File=1e30d111d2654524a7967353314f1529765aTR

Corbin, C. H., T. G. O'Quinn, A. J. Garmyn, J. F. Legako, M. R. Hunt, T. T. N. Dinh, R. J. Rathmann, J. C. Brooks, and M. F. Miller. 2015. Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments. Meat Sci. 100:24–31. Available from: http://www.sciencedirect.com/science/article/pii/S0309174014002988

Corrêa, C. E. S., M. N. Pereira, S. G. de Oliveira, and M. H. Ramos. 2003. Performance of Holstein cows fed sugarcane or corn silages of different grain textures. Sci. Agric. 60:621–629. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90162003000400003&lng=en&nrm=iso&tlng=es

Costa, M. G., J. M. De Souza Campos, S. De Campos Valadares Filho, R. F. D. Valadares, S. De Souza Mendonça, D. De Paula Souza, and M. Da Paschoa Teixeira. 2005. Desempenho produtivo de vacas leiteiras alimentadas com diferentes properções de cana-de-açúcar e concentrado ou silagem de milho na dieta. Rev. Bras. Zootec. 34:2437–2445.

Cundiff, L., R. Koch, K. Gregory, J. Crouse, and M. Dikeman. 1993. Characteristics of Diverse Breeds in Cycle IV of the Cattle Germplasm EvaluationProgram. Rom. L. Hruska U.S. Meat Anim. Res. Cent. Available from: http://digitalcommons.unl.edu/hruskareports/119

Daley, C. A., A. Abbott, P. S. Doyle, G. A. Nader, and S. Larson. 2010. A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. Nutr. J. 9:10. Available from: http://www.nutritionj.com/content/9/1/10

Damon, R., and R. Crown. 1960. Carcass characteristics of purebred and crossbred beef steers in the Gulf Coast Region. J. Anim. …. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/19/3/JAN0190030820

Daniel, J. L. P., M. C. Santos, M. Zopollatto, P. Huhtanen, and L. G. Nussio. 2013. A data-analysis of lime addition on the nutritive value of sugarcane in Brazil. Anim. Feed Sci. Technol. 184:17–23. Available from: http://www.sciencedirect.com/science/article/pii/S0377840113001296

Dias, A. M., L. C. V. Ítavo, J. C. Damasceno, G. T. dos Santos, C. C. B. F. Ítavo, F. F. da Silva, É. Nogueira, and C. M. Soares. 2011. Sugar cane treated with calcium hydroxide in diet for cattle: intake, digestibility of nutrients and ingestive behaviour. Rev. Bras. Zootec. 40:1799–1806. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-35982011000800025&lng=en&nrm=iso&tlng=en

Dikeman, M., and C. Devine. 2014. Encyclopedia of Meat Sciences: 3-volume set. Elsevier Science. Available from: https://books.google.com/books?id=vL9dAwAAQBAJ&pgis=1

Domestic Consumption / Meat, Beef and Veal / Honduras / Meat / USDA Report / AgroChart. Available from: http://www.agrochart.com/en/usda/section/20/meat/country/116/honduras/commodity/223/meat-beef-and-veal/attribute/10/domestic-consumption/

Donefer, E., L. James, and C. Laurie. 1975. Use of sugar cane-derived feedstock for livestock Proc III Wld Conf Anim Prod Melbourne. Available from: https://scholar.google.com/scholar?hl=en&q=donefer+et+al+1975&btnG=&as_sdt=1%2C44&as_sdtp=#0

Dressing Percentage of Slaughter Cattle. Available from: http://www.thebeefsite.com/articles/759/dressing-percentage-of-slaughter-cattle/

Erwin, E., G. Marco, and E. Emery. 1961. Volatile Fatty Acid Analyses of Blood and Rumen Fluid by Gas Chromatography. J. Dairy …. Available from: http://www.journalofdairyscience.org/article/S0022-0302(61)89956-6/abstract

Ferreiro, H., and T. Preston. 1977. Digestibility and voluntary intake of derinded sugar cane stalk with and without addition of cane tops. Trop. Anim. Prod. Available from: https://scholar.google.com/scholar?q=ferreiro+and+preston+1977+cane+tops&btnG=&hl=en&as_sdt=0%2C44#0

Finch, V.A., 1984. Heat as a stress factor in herbivores under tropical conditions. In: Gilchrist, F.M.C., Mackie, R.I. (Eds.), Herbivore Nutrition in the Subtropics and Tropics. The Science Press, Graighall, South Africa, pp. 89–105.

Foutz, C. P., H. G. Dolezal, T. L. Gardner, D. R. Gill, J. L. Hensley, and J. B. Morgan. 1997. Anabolic implant effects on steer performance, carcass traits, subprimal yields, and longissimus muscle properties. J. Anim. Sci. 75:1256–65. Available from: http://europepmc.org/abstract/med/9159272

Frassinetti, M. A. 1972. Estructura agraria y latifundio: el caso de Honduras. Universidad Nacional Autónoma de Honduras, Centro Universitario de Estudios Generales, Departamento de Ciencias Sociales. Available from: https://books.google.com/books/about/Estructura_agraria_y_latifundio.html?id=CIFykgAACAAJ&pgis=1

French, P., E. . O'Riordan, F. . Monahan, P. . Caffrey, M. Vidal, M. . Mooney, D. . Troy, and A. . Moloney. 2000. Meat quality of steers finished on autumn grass, grass silage or concentrate-based diets. Meat Sci. 56:173–180. Available from: http://www.sciencedirect.com/science/article/pii/S0309174000000371
G2077 Feeding Poultry Litter to Beef Cattle | University of Missouri Extension. Available from: http://extension.missouri.edu/p/G2077

Gallo, P., M. Pereira, and M. Andrade. 2000. Effect of dietary sugarcane concentration on heifer growth. J. Dairy Sci. Available from: https://scholar.google.com/scholar?q=gallo+pereira+2000+dietary+sugarcane&btnG=&hl=en&as_sdt=0%2C44#0

Gonzalez, I. and Williams, A. 1976. Preliminary investigations on derinded sugar cane as cattle feed Trop Animal Prod 1:227 abs

Harris, J. J., H. R. Cross, and J. W. Savell. History of Meat Grading in the United States. Available from: http://meat.tamu.edu/meat-grading-history/

Harrison, A. R., M. E. Smith, D. M. Allen, M. C. Hunt, C. L. Kastner, and D. H. Kropf. 1978. Nutritional regime effects on quality and yield characteristics of beef. J. Anim. Sci. 47:383–388. Available from: http://krex.k-state.edu/dspace/handle/2097/851

Humphries, S. 1998. Milk Cows, Migrants, and Land Markets: Unraveling the Complexities of Forest-to-Pasture Conversion in Northern Honduras. Econ. Dev. Cult. Change. Available from: http://www.jstor.org/stable/10.1086/452388

Immonen, K., M. Ruusunen, K. Hissa, and E. Puolanne. 2000a. Bovine muscle glycogen concentration in relation to finishing diet, slaughter and ultimate pH. Meat Sci. 55:25–31. Available from: http://www.sciencedirect.com/science/article/pii/S0309174099001217

Immonen, K., M. Ruusunen, and E. Puolanne. 2000b. Some effects of residual glycogen concentration on the physical and sensory quality of normal pH beef. Meat Sci. 55:33–38. Available from: http://www.sciencedirect.com/science/article/pii/S0309174099001229

Jackson, M. G. 1977. Review article: The alkali treatment of straws. Anim. Feed Sci. Technol. 2:105–130.

Jeremiah, L., Z. L. Carpenter, G. C. Smith, and O. D. Butler. 1970. Marbling as an indicator of beef palatability. Tex Agr Exp Sta Consol. Progr Rep. Available from: http://agris.fao.org/agris-search/search.do?recordID=US201301138307

Johnson, B. J., P. T. Anderson, J. C. Meiske, and W. R. Dayton. 1996a. Effect of a combined trenbolone acetate and estradiol implant on feedlot performance, carcass characteristics, and carcass composition of feedlot steers. J. Anim. Sci. 74:363–371. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/74/2/363

Johnson, B. J., N. Halstead, M. E. White, M. R. Hathaway, A. DiCostanzo, and W. R. Dayton. 1998. Activation state of muscle satellite cells isolated from steers implanted with a combined trenbolone acetate and estradiol implant. J. Anim. Sci. 76:2779–2786. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/76/11/2779

Johnson, B. J., M. R. Hathaway, P. T. Anderson, J. C. Meiske, and W. R. Dayton. 1996b. Stimulation of circulating insulin-like growth factor I (IGF-I) and insulin-like growth factor binding proteins (IGFBP) due to administration of a combined trenbolone acetate and estradiol implant in feedlot cattle. J. Anim. Sci. 74:372–379. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/74/2/372?search-result=1

Jones, S. D. M., R. E. Rompala, J. W. Wilton, and C. H. Watson. 1984. Empty body weights, carcass weights and offal proportions in bulls and steers of different mature size. Can. J. Anim. Sci. 64:53–57. Available from: http://pubs.aic.ca/doi/abs/10.4141/cjas84-007

Jr, F. P. 1974. Relationship of marbling to meat tenderness. Proc. Meat Ind. Res. Conf. Available from: https://scholar.google.com/scholar?q=Parrish+1974+marbling&btnG=&hl=en&as_sdt=0%2C44#0

Kerth, C. R., K. W. Braden, R. Cox, L. K. Kerth, and D. L. Rankins. 2007. Carcass, sensory, fat color, and consumer acceptance characteristics of Angus-cross steers finished on ryegrass (Lolium multiflorum) forage or on a high-concentrate diet. Meat Sci. 75:324–31. Available from: http://www.sciencedirect.com/science/article/pii/S0309174006002786

Koch, R. M., M. E. Dikeman, and J. D. Crouse. 1982. Characterization of Biological Types of Cattle (Cycle III).III. Carcass Composition, Quality and Palatability. J. Anim. Sci. 54:35–45. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/54/1/JAN0540010035

Koohmaraie, M., and G. H. Geesink. 2006. Contribution of postmortem muscle biochemistry to the delivery of consistent meat quality with particular focus on the calpain system. Meat Sci. 74:34–43. Available from: http://www.sciencedirect.com/science/article/pii/S0309174006001355

Koohmaraie, M. 1994. Muscle proteinases and meat aging. Meat Sci. 36:93–104. Available from: http://www.sciencedirect.com/science/article/pii/0309174094900361

Legako, J. F., T. T. N. Dinh, M. F. Miller, K. Adhikari, and J. C. Brooks. 2016. Consumer palatability scores, sensory descriptive attributes, and volatile compounds of grilled beef steaks from three USDA Quality Grades. Meat Sci. 112:77–85. Available from: http://www.sciencedirect.com/science/article/pii/S0309174015301133

Leng, R., and T. Preston. 1976. Sugar cane for cattle production, present constraints, perspectives and research priorities. Trop Anim Prod. Available from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.472.6593&rep=rep1&type=pdf

Marti, D., R. Johnson, and K. Mathews. 2011. Where's the (not) Meat?: Byproducts from Beef and Pork Production. USDA Econ. Res. Serv. Available from: http://162.79.45.209/media/147867/ldpm20901.pdf

Martin, S., and M. McCann. 1998. Microbiological survey of Georgia poultry litter. … Appl. Poult. … 7:90–98. Available from: http://japr.oxfordjournals.org/content/7/1/90.short

Mathews, K. H., M. J. Vandeveer, and R. A. Gustafson. 2006. An Economic Chronology of Bovine Spongiform Encephalopathy in North America - ldpm14301_002.pdf. Available from: http://www.ers.usda.gov/media/862398/ldpm14301_002.pdf

Mathews, K. H. 2008. Economic Impacts of Feed-Related Regulatory Responses to Bovine Spongiform Encephalopathy. Available from: http://usda.mannlib.cornell.edu/usda/ers/LDP-M/2000s/2008/LDP-M-09-04-2008_Special_Report.pdf

McBee, J. L., and J. A. Wiles. 1967. Influence of Marbling and Carcass Grade on the Physical and Chemical Characteristics of Beef. J. Anim. Sci. 26:701–704. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/26/4/JAN0260040701?search-result=1

McCaughey, W. P., and R. L. Cliplef. 1996. Carcass and organoleptic characteristics of meat from steers grazed on alfalfa/grass pastures and finished on grain. Can. J. Anim. Sci. 76:149–152. Available from: http://www.nrcresearchpress.com/doi/abs/10.4141/cjas96-021#.VtRqxMfJBjU

McIntyre, B., and W. Ryan. 1984. The influence of type of diet and electrical stimulation on the eating quality of beef. Anim. Prod. Aust. Available from: https://scholar.google.com/scholar?q=McIntyre+and+ryan+1984&btnG=&hl=en&as_sdt=0%2C44#0

McKenna, D. R., D. L. Roeber, P. K. Bates, T. B. Schmidt, D. S. Hale, D. B. Griffin, J. W. Savell, J. C. Brooks, J. B. Morgan, T. H. Montgomery, K. E. Belk, and G. C. Smith. 2002. National Beef Quality Audit-2000 : Survey of targeted cattle and ... J. Anim. Sci. 80:1212–1222.

Méndez, R. D., C. O. Meza, J. M. Berruecos, P. Garcés, E. J. Delgado, and M. S. Rubio. 2009. A survey of beef carcass quality and quantity attributes in Mexico. J. Anim. Sci. 87:3782–3790.

Menezes, G. C. de C., S. de C. Valadares Filho, F. A. Magalhães, R. F. D. Valadares, L. F. Prados, E. Detmann, O. G. Pereira, and M. I. Leão. 2011. Intake and performance of confined bovine fed fresh or ensilaged sugar cane based diets and corn silage. Rev. Bras. Zootec. 40:1095–1103. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-35982011000500022&lng=en&nrm=iso&tlng=en

Miller, M. F., M. A. Carr, C. B. Ramsey, K. L. Crockett, and L. C. Hoover. 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79:3062–3068. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/79/12/3062

Miller, M. F., L. C. Hoover, K. D. Cook, A. L. Guerra, K. L. Huffman, K. Tinney, C. B. Ramsey, H. C. Brittin, and L. M. Huffman. 1995. Consumer Acceptability of Beef Steak Tenderness in the Home and Restaurant. J. Food Sci. 60:963–965. Available from: http://doi.wiley.com/10.1111/j.1365-2621.1995.tb06271.x

Mohamed, W. Z., and A. R. Alimon. 2003. Use of palm kernel cake and oil palm by-products in compound feed. Palm Oil Dev.:5–9. Available from: http://www.chgs.com.my/download/Palm Oil Developments/june 2004/Use of Palm Kernel Cake and Oil Palm By-products in Compound Feed.pdf

Morgan, J. 1997. Implant program effects on USDA beef carcass quality grade traits and meat tenderness. Res. Rep. P. Available from: http://agris.fao.org/agris-search/search.do?recordID=US201302868104

NAMP. 2007. The Meat Buyers Guide. John Wiley & Sons, Reston, VA.

Neto, A., Á. Bispo, and D. Junges. 2012. Sugarcane silage replacing corn silage in lactating dairy cows rations. XVI. Available from: http://www.researchgate.net/profile/Jalil_Ghassemi_Nejad/publication/236592780_A_comparison_of_feeding_whole_crop_barley_mixed_with_Italian_ryegrass_silage_versus_tall_fescue_hay_for_Holstein_growing_cattle/links/004635182664cbdb14000000.pdf#page=487

Noland, P. R., B. F. Ford, and M. L. Ray. 1955. The Use of Ground Chicken Litter as a Source of Nitrogen for Gestating-Lactating Ewes and Fattening Steers. J. Anim. Sci. 14:860–865.

Nuernberg, K., D. Dannenberger, G. Nuernberg, K. Ender, J. Voigt, N. D. Scollan, J. D. Wood, G. R. Nute, and R. I. Richardson. 2005. Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. Livest. Prod. Sci. 94:137–147. Available from: http://www.sciencedirect.com/science/article/pii/S0301622604002738

O'Quinn, T. G., J. C. Brooks, R. J. Polkinghorne, A. J. Garmyn, B. J. Johnson, J. D. Starkey, R. J. Rathmann, and M. F. Miller. 2012. Consumer assessment of beef strip loin steaks of varying fat levels. J. Anim. Sci. 90:626–34. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/90/2/626

Page, N. H. S. S. H., and N. N. W. S. US Department of Commerce. National Weather Service. Available from: http://www.nws.noaa.gov/om/heat/heat_index.shtml

Paschal, J. C., J. O. Sanders, J. L. Kerr, D. K. Lunt, and a D. Herring. 1995. Postweaning and Feedlot Growth and Carcass Characteristics of Angus-, Gray Brahman-, Gir-, Indu-Brazil-, Nellore-, and Red Brahman-Sired F1 Calves. J. Anim. Sci.:373–380.

Pate, F., J. Alvarez, J. Phillips, and B. Eiland. 1984. Sugarcane as a cattle feed: production and utilization. Available from: http://corn.agronomy.wisc.edu/crops/sugarcane.pdf

Pearson, A. M. 1966. Desirability of Beef—Its Characteristics and Their Measurement. J. Anim. Sci. 25:843–854. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/25/3/JAN0250030843?search-result=1

Preston, R. L., R. D. Vance, V. R. Cahill, and S. W. Kock. 1974. Carcass Specific Gravity and Carcass Composition in Cattle and the Effect of Bone Proportionality on this Relationship. J. Anim. Sci. 38:47–51. Available from: https://www.animalsciencepublications.org/publications/jas/abstracts/38/1/JAN0380010047?search-result=1

Preston, T. R. 1977. Nutritive value of sugar cane for ruminants. Trop. Anim. Prod. Available from: http://www.fao.org/waicent/Faoinfo/Agricult/aGa/AGAP/FRG/tap22/2_2_1.PDF

Priego, A., A. Wilson, and T. Sutherland. 1977. The effect on parameters of rumen fermentation, rumen volume and fluid flow rate of Zebu bulls given chopped sugar cane supplemented with rice polishings or. Anim. Prod. Available from: http://www.fao.org/Ag/AGA/AGAP/FRG/tap23/2_3_7.pdf

Realini, C. E., S. K. Duckett, G. W. Brito, M. Dalla Rizza, and D. De Mattos. 2004. Effect of pasture vs. concentrate feeding with or without antioxidants on carcass characteristics, fatty acid composition, and quality of Uruguayan beef. Meat Sci. 66:567–77. Available from: http://www.sciencedirect.com/science/article/pii/S0309174003001608

Ruhl, J. M. 1984. Journal of Interamerican Studies and World Affairs. J. Inter. Am. Stud. World Aff. 26:33–68. Available from: http://www.jstor.org/stable/165506

Sally Humphries. 1998. Milk Cows, Migrants, and Land Markets: Unraveling the Complexities of Forest-to-Pasture Conversion in Northern Honduras. Econ. Dev. Cult. Change 47:95–124 CR – Copyright © 1998 The University . Available from: http://www.jstor.org/stable/10.1086/452388

Samber, J. A., J. D. Tatum, M. I. Wray, W. T. Nichols, J. B. Morgan, and G. C. Smith. 1996. Implant program effects on performance and carcass quality of steer calves finished for 212 days. J. Anim. Sci. 74:1470–1476. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/74/7/1470

Schaake, S. L., G. C. Skelley, E. Halpin, L. W. Grimes, R. B. Brown, D. L. Cross, and C. E. Thompson. 1993. Carcass and meat sensory traits of steers finished on fescue and clover, summer forage, or for different periods in drylot. J. Anim. Sci. 71:3199–3205. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/71/12/3199

Schnell, T. D., K. E. Belk, J. D. Tatum, R. K. Miller, and G. C. Smith. 1997. Performance, carcass, and palatability traits for cull cows fed high-energy concentrate diets for 0, 14, 28, 42, or 56 days. J. Anim. Sci. 75:1195–1202. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/75/5/1195

Schoonhoven, A. D., F. Holmann, P. Argel, E. Perez, J. C. Ordoñez, and J. Chaves. 2006. Estimation and comparison of benefits due to feeding hay and silage during the dry season on commercial dual-purpose cattle production systems in Honduras and Costa Rica. Livest. Res. Rural Dev. Available from: http://www.lrrd.cipav.org.co/lrrd18/1/scho18015.htm

Schroeder, J. W., D. A. Cramer, R. A. Bowling, and C. W. Cook. 1980. Palatability, Shelflife and Chemical Differences between Forage- and Grain-Finished Beef. J. Anim. Sci. 50:852–859. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/50/5/JAN0500050852

Seggern, D. D. Von, C. R. Calkins, D. D. Johnson, J. E. Brickler, and B. L. Gwartney. 2005. Muscle profiling: Characterizing the muscles of the beef chuck and round. Meat Sci. 71:39–51. Available from: http://www.sciencedirect.com/science/article/pii/S0309174005001269

Shackelford, S. D., M. Koohmaraie, M. F. Miller, J. D. Crouse, and J. O. Reagan. 1991. An evaluation of tenderness of the longissimus muscle of Angus by Hereford versus Brahman crossbred heifers. J. Anim. Sci. 69:171–177. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/69/1/171

Shackelford, S. D., M. Koohmaraie, G. Whipple, T. L. Wheeler, M. F. Miller, J. D. Crouse, and J. O. Reagan. 1991. Predictors of beef tenderness: development and verification. J. food Sci. an Off. Publ. Inst. Food Technol. Available from: http://agris.fao.org/agris-search/search.do?recordID=US9157161

Silanikove, N., Z. Holzer, D. Cohen, R. Benjamin, M. Gutman, and a Meltzer. 1987. Interrelationship between metabolism of tritiated water, 22sodium and dry matter intake by beef cattle consuming wheat straw and poultry litter in free choice. Comp. Biochem. Physiol. A Comp. Physiol. 88:113–118.

Silanikove, N., and D. Tiomkin. 1992. Toxicity induced by poultry litter consumption: effect on measurements reflecting liver function in beef cows. Anim. Prod. 54:203–209. Available from: http://www.journals.cambridge.org/abstract_S0003356100036813

Silanikove, N. 1992. Effects of water scarcity and hot environment on appetite and digestion in ruminants: a review. Livest. Prod. Sci. 30:175–194. Available from: http://www.sciencedirect.com/science/article/pii/S0301622606800096

Silanikove, N. 2000. Effects of heat stress on the welfare of extensively managed domestic ruminants. Livest. Prod. Sci. 67:1–18. Available from: http://www.sciencedirect.com/science/article/pii/S0301622600001627

Simonne, A. H., N. R. Green, and D. I. Bransby. 1996. Consumer Acceptability and p-Carotene Content of Beef as Related to Cattle Finishing Diets. J. Food Sci. 61:1254–1257. Available from: http://doi.wiley.com/10.1111/j.1365-2621.1996.tb10973.x

Slutsky, D. 1979. La agroindustria de came en Honduras.

Smith, G. C., Z. L. Carpenter, H. R. Cross, C. E. Murphey, H. C. Abraham, J. W. Savell, G. W. Davis, B. W. Berry, and F. C. Parrish. 1985. Relationship of USDA marbling groups to palatability of cooked beef. J. Food Qual. 7:289–308. Available from: http://doi.wiley.com/10.1111/j.1745-4557.1985.tb01061.x

Smith, G. C., J. W. Savell, H. R. Cross, Z. L. Carpenter, C. E. Murphey, G. W. Davis, H. C. Abraham, F. C. Parrish, and B. W. Berry. 1987. Relationship of USDA quality grades to palatability of cooked beef. J. Food Qual. 10:269–286. Available from: http://doi.wiley.com/10.1111/j.1745-4557.1987.tb00819.x

Smith, J., K. Sones, D. Grace, S. MacMillan, S. Tarawali, and M. Herrero. 2012. Beyond milk, meat, and eggs: Role of livestock in food and nutrition security. Anim. Front. 3:6–13. Available from: https://dl.sciencesocieties.org/publications/af/abstracts/3/1/6

Sunderlin, W. D., and J. A. Rodriguez. 1996. Cattle, broadleaf forests and the agricultural modernization law of Honduras: the case of Olancho. Available from: http://www.cifor.org/library/54/cattle-broadleaf-forests-and-the-agricultural-modernization-law-of-honduras-the-case-of-olancho/

Tatum, J. D., K. E. Belk, T. G. Field, J. A. Scanga, and G. C. Smith. 2006. Relative Importance of Weight , Quality Grade , and Yield Grade as Drivers of Beef Carcass Value in Two Grid-Pricing Systems. Prof. Anim. Sci. 22:41–47.

Tume, R. K., and A. Yang. 1996. Fat color in beef. In: Meat Focus International. p. 81.

USDA. 1997. Official United States Standards for Grades of Carcass Beef.

USDA. 2010. Institutional Meat Purchase Specifications: Fresh Beef Series 100. Agricultural Marketing Service, USDA, Washington, DC.

Weather and Climate: San Pedro Sula, Honduras, average monthly , Rainfall (millimeter), Temperatures (celsius), Humidity, Wind Speed. Available from:

https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,San-Pedro-Sula,Honduras

Wheeler, T. L., L. V Cundiff, and R. M. Koch. 1994. Effect of marbling degree on beef palatability in Bos taurus and Bos indicus cattle. J. Anim. Sci. 72:3145–3151. Available from: https://www.animalsciencepublications.org/publications/jas/articles/72/12/3145

Whipple, G., M. Koohmaraie, M. E. Dikeman, J. D. Crouse, M. C. Hunt, and R. D. Klemm. 1990. Evaluation of attributes that affect longissimus muscle tenderness in Bos taurus and Bos indicus cattle. J. Anim. Sci. 68:2716–2728.

X-Rite. 2007. A Guide to Understanding Color Communication. In: A Guide to Understanding Color Communication. p. 1–26. Available from: http://www.xrite.com/documents/literature/en/L10-001_Understand_Color_en.pdf

Young, L. D., L. V. Cundiff, J. D. Crouse, G. M. Smith, and K. E. Gregory. 1978. Characterization of Biological Types of Cattle. VIII. Postweaning Growth and Carcass Traits of Three-Way Cross Steers. J. Anim. Sci. 46:1178–1191. Available from: https://dl.sciencesocieties.org/publications/jas/abstracts/46/5/JAN0460051178

APPENDIX A
SUPPORTIVE DESCRIPTIVE CHARTS

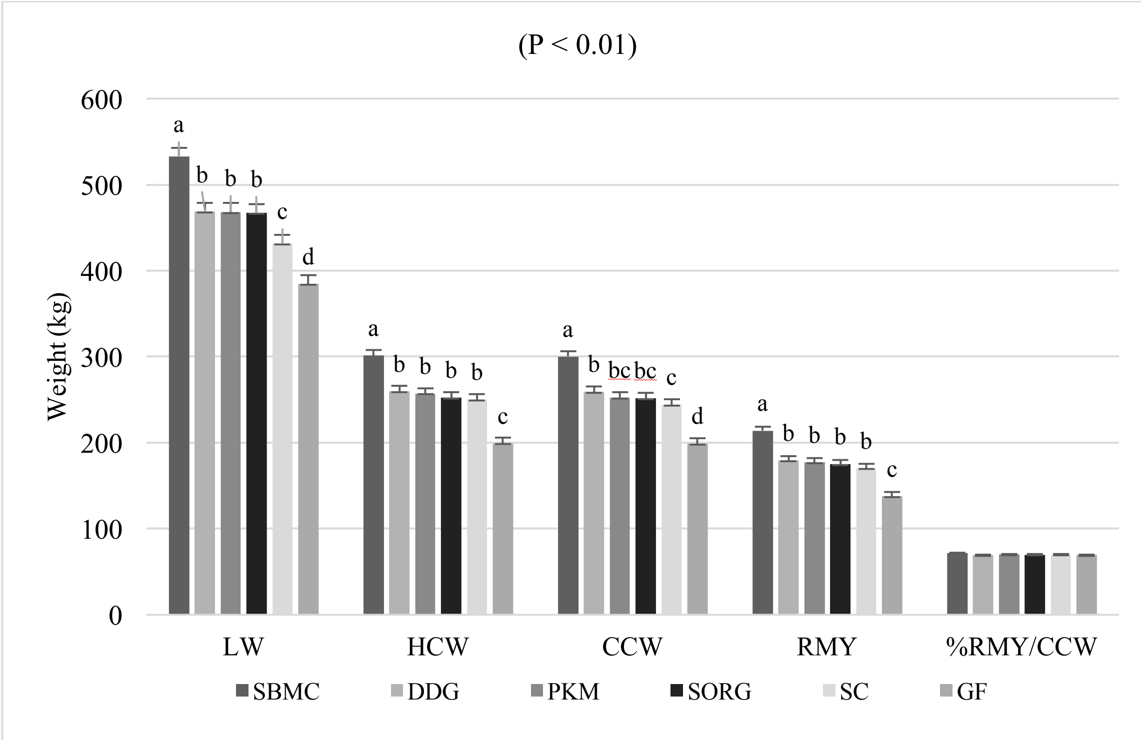

Figure A.1 Treatment effect on weight and red meat yield

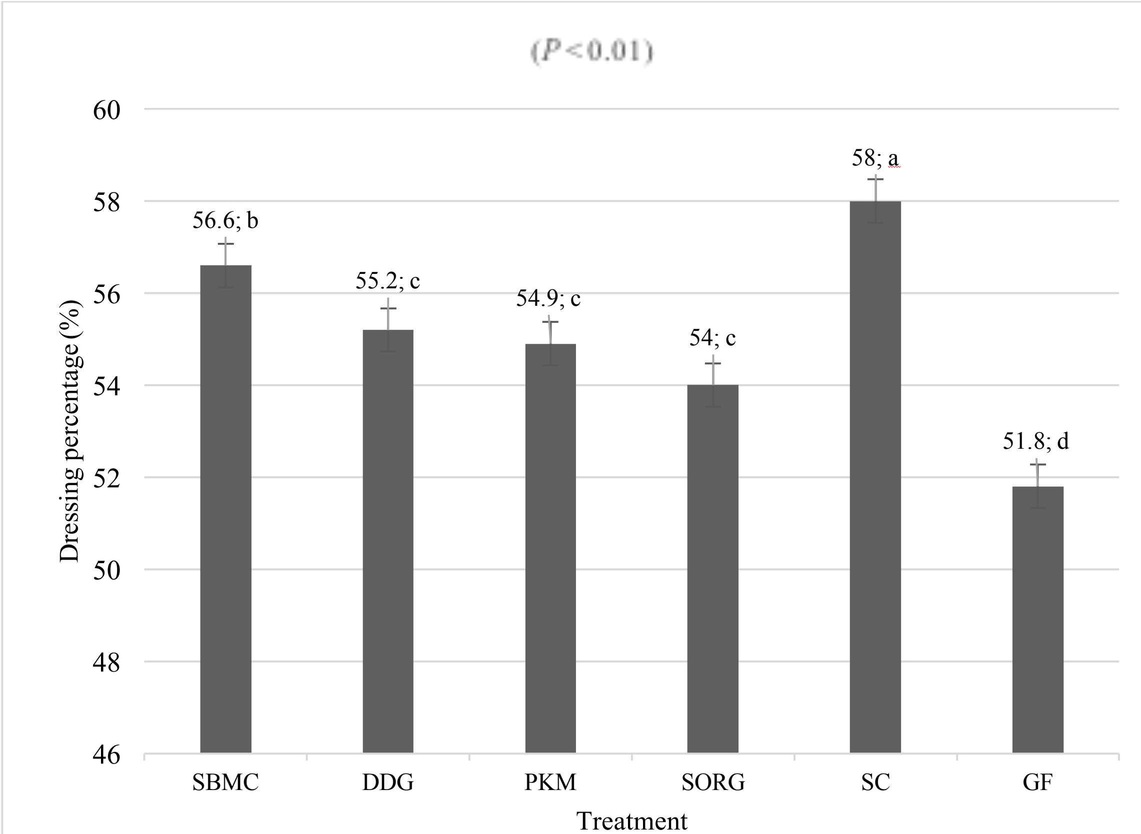

Figure A.2 Treatment effect on dressing percentage

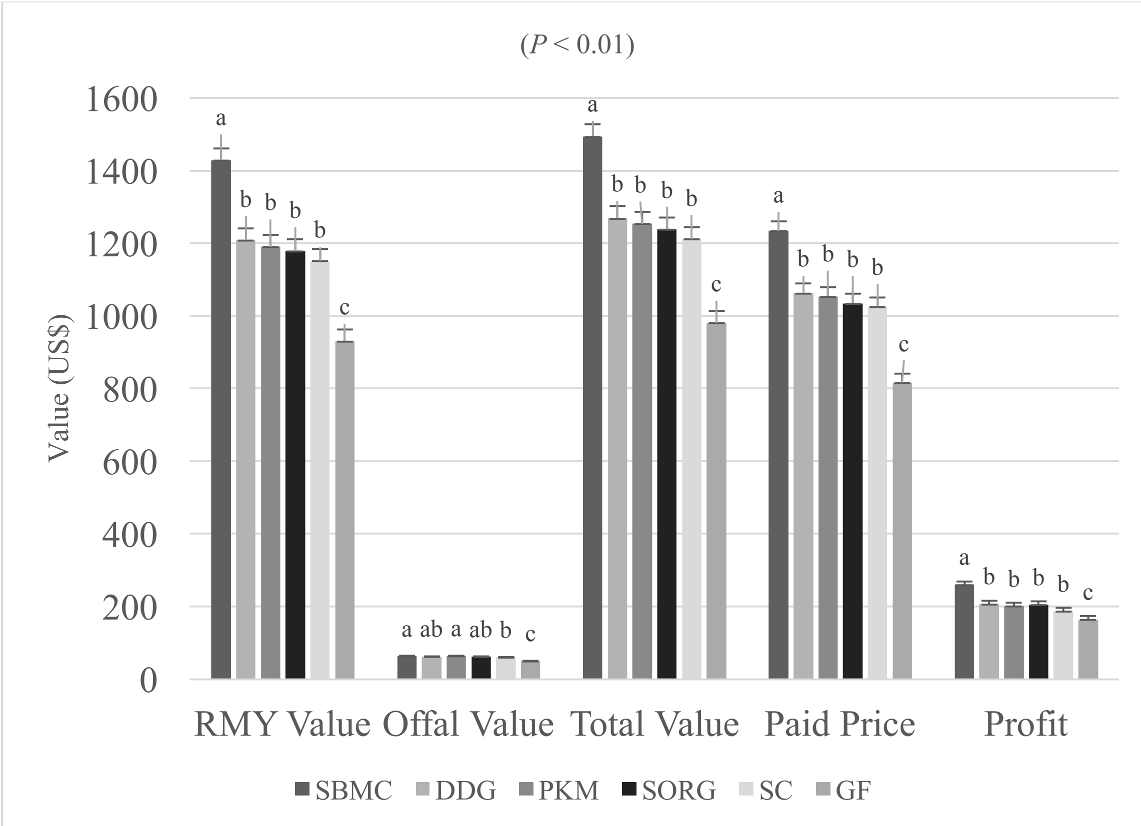

Figure A.3 Treatment effect on value